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ABSTRACT

This document is a student manual for a general mechanical repair course. Following a list of common essential elements of trade and industrial education, the manual is divided into three sections. The first section, on minor automotive maintenance, contains 13 units: automotive shop safety; engine principles; fuel system operation and repair; electrical system; ignition systems; lubrication systems; engine cooling system; exhaust system; wheels and tires; brake and bearing systems; frame, suspension, and steering; drive line; and cleaning the car. Six units on small engine repair in section 2 are contains 13 units: as follows: engine principles; principles of carburetion; lubrication systems; starter systems; measurement and instruments; and troubleshooting. The third section contains six units on welding: introduction to welding; oxyacetylene welding positions and applications; using the cutting torch; introduction to shielded metal arc welding; welding joints and positions; and metallic inert-gas welding. Each unit has the following elements: unit name; topic; essential elements; unit objective; specific objective(s); basic academic skills application; transparency masters; assignment sheet(s); and job sheet(s). Three appendices contain formulas, tools, and tool list. (NLA)

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Student Manual

General Mechanical Repair

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Minor Automotive Maintenance
Small Engine
Welding

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GENERAL MECHANICAL REPAIR

Student Materials

Prepared by

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Curriculum Specialist

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Commerce, Texas

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Chilton Repair Manual

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Larry Hamlin
Curriculum Specialist
Trade and Industrial Education

PREFACE

The Educational Development and Training Center at East Texas State University is striving to provide needed materials to vocational instructors within the state.

The purpose of this publication is to assist instructors in improving instruction. As these materials are used, it is hoped that student performance will improve and students will be better prepared to assume a role in the field of General Mechanical Repair.

Instructional materials in this publication are written in terms of student performance, using measurable objectives. This approach augments the teaching-learning process. Criterion-referenced evaluation instructions are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas, including progress and the finished product.

The instructor should, where appropriate, reinforce the application of basic academic skills. For example, when addressing the area of study, the instructor should stress to students that they will be applying specific mathematical skills such as addition, subtraction, multiplication, and division that they have learned in previous academic courses. Effective teaching practices research, and consequently the Texas Teacher's Appraisal System, emphasizes the relationship of new learning to prior or future learning. In some cases, specific academic skills needed to complete job tasks may not have yet been addressed in the academic courses in which the students have been enrolled. If this is the case, the vocational instructor should introduce and explain the academic skills, and students should achieve a level of mastery that will allow them to perform the job tasks. Instructors of vocational courses are encouraged to work closely with instructors of academic courses to ensure that students are taught fundamental academic principles correctly.

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital areas of instruction (motivation, personalization, and localization) are not included in this publication; however, they should be capitalized on by the instructor. Only then will this publication really become a vital part of the teaching-learning process.

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COMMON ESSENTIAL ELEMENTS

75.88 Trade and Industrial Education

(a) The elements in this subsection are common to all trade and industrial courses unless otherwise indicated and shall be included in each course at the appropriate level. They are described here to preclude repetitions in each course. Every school offering trade and industrial education shall provide courses which include the following essential elements:

(1) Leadership concepts and skills. The student shall be provided opportunities to:

(A) demonstrate skills, characteristics, and responsibilities of leaders and effective group members;

(B) demonstrate a knowledge of parliamentary procedure principles;

(C) plan and conduct leadership activities; and

(D) prepare for effective citizenship and for participation in our democratic society.

(2) Concepts and skills related to successful employment and/or postsecondary training. The student shall be provided opportunities to:

(A) identify employment opportunities and preparation requirements in chosen fields;

(B) identify effective methods to secure and terminate employment;

(C) demonstrate effective communication skills both oral and written and follow through on assigned tasks;

(D) demonstrate dependability and punctuality;

(E) demonstrate productive work habits and attitudes;

(F) understand the importance of taking pride in the quality of work performed;

(G) recognize the dignity in work;

(H) develop skills in planning and organizing work;

(I) apply required methods and sequences when performing tasks;

(J) apply principles of time management and work simplification when performing assigned tasks;

(K) identify ethical practices and responsibilities; and

(L) understand the importance of the application of organizational policies and procedures.

(3) Concepts and skills associated with entrepreneurship. The student shall be provided opportunities to:

(A) identify opportunities for business ownership;

(B) understand the risk and profit motive factor;

(C) understand the elements and advantages of the free enterprise system; and

(D) explain the role of small business in the free enterprise system.

(4) Concepts and skills related to safety and safe working conditions. The student shall be provided opportunities to identify and apply safe working practices to all training situations.

(5) Concepts and skills associated with human relations and personality development. The student shall be provided opportunities to:

(A) understand the importance of maintaining good health and proper appearance for effective job performance;

(B) understand oneself and others;

(C) exercise self-control;

(D) accept and use criticism;

(E) recognize basic human relationships as they relate to business success; and

(F) demonstrate characteristics for successful working relationships.

(6) Concepts and skills related to personal and business management. The student shall be provided opportunities to:

(A) explain how management assists in reaching personal and family goals;

(B) explain the management process;

(C) describe the role of management in controlling stress;

(D) identify and understand personal checking accounts;

(E) identify and understand personal loan application processes;

(F) identify and understand different financial institutions;

(G) identify the role and function of business management:

(H) understand the lines of authority; and

(I) identify effective supervisory techniques.

(7) Concepts and skills associated with the specific occupation being taught. The student shall be provided opportunities to:

(A) understand the basic concepts of and develop proficiency in the occupational area for which instruction/training is provided;

(B) develop a fundamental understanding of mathematical principles and scientific procedures;

(C) understand terminology utilized;

(D) identify tools, equipment, and materials used; and

(E) develop and demonstrate appropriate techniques for the selection, use, maintenance, and storage of tools, equipment, and materials.

(ddd)Coordinated vocational-academic education (CVAE)—general mechanical repair (2-3 units) shall include the essential trade and industrial education elements and the following essential elements:

(1) Concepts and skills associated with automobile mechanics. The student shall be provided opportunities to:

(A) understand the functions of the major automobile components;

(B) perform basic preventive maintenance functions on the automobile;

(C) demonstrate proper techniques in performing a tune-up on an automobile; and

(D) remove, repair, and replace automobile brake system components.

(2) Concepts and skills associated with small engine repair. The student shall be provided opportunities to:

(A) understand the functions of the small gasoline engine and its components;

(B) identify types of small gasoline engines;

(C) understand the proper fuel and fuel mixtures required for various types of small engines;

(D) service and repair small engine fuel systems, lubrication systems, and starting systems; and

(E) troubleshoot and repair small engines.

(3) Concepts and skills associated with welding. The student shall be provided opportunities to:

(A) understand the basic theory of oxyfuel welding, brazing, and cutting;

(B) utilize the oxyfuel cutting process to produce freehand cuts;

(C) weld and braze metal plate using the oxyfuel process;

(D) understand the basic theory of shielded metal arc welding; and

(E) utilize the shielded metal arc process to weld butt and tee joints on metal plate.

II-1-IS

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Automotive Shop Safety

TOPIC: Safety

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to identify safety and point out unsafe practices in the automotive shop.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will participate in safety operations and practices in the automotive shop.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used when studying automotive shop safety include reading concepts, oral and written communications and mathematics.*

Safety

A. Definitions

1. Safety: Minimizing harm and risk in the workplace to eliminate accidents.
2. Personal safety: Protecting yourself from injury caused by your own or another worker's actions.
3. Group safety: Protecting other workers from hazardous situations caused by neglect, abuse, or ignorance.

B. Importance in the laboratory and on the job

1. In any classroom, especially in a laboratory where tools and equipment are used, the chances of an accident occurring are high if the proper safe working practices are not demonstrated by everyone at all times.
2. Even though emphasis is placed on safety during the training program, once someone actually begins work, oftentimes the employer takes for granted employees' awareness of safety procedures. Learn now before it is too late!

3. Students and employees have been injured, and some have lost their lives, simply because they did not follow the rules of safety.
4. Accidents can be prevented, both in the classroom and in the work place.

C. Attitudes

1. A proper attitude is a must in every automotive shop. This makes the work area a smoothly running and safe place. A proper attitude is demonstrated by workers obeying all shop safety rules, proper use and care of tools, cleanliness and order in the work area, and consideration for other workers. A proper attitude minimizes the possibility of accidents, and ensures that the job is well done.
2. Respect safety—do not take for granted that accidents will not happen to you. That is what others thought before they were seriously injured.
3. At all times, be on guard for possible hazards.

D. Causes of Accidents

1. Horseplay
2. Inadequate lighting
3. Undesirable location of equipment
4. Low ceilings
5. Unguarded belts, gears, pulleys, blades, cutters, etc.
6. Failure to allow for adequate safety zones around equipment
7. Improper type and location of switches
8. Poorly located, constructed, and maintained storage
9. Waste materials, stock supplies, or liquids on the floor
10. Improperly maintained tools and equipment
11 Improper use of tools and equipment
12. Failure to use protective equipment (Safety glasses are a must)
13. Inadequate ventilated work areas
14. Failure to adhere to personal grooming standards as related to the operation of equipment and/or the use of tools.

    Examples: Loose clothing; dangling jewelry; long, loose hair
15. Use of alcohol or drugs by workers

E. Clothing

1. Wear appropriate clothing. It should be loose fitting. Roll up sleeves. Remove all rings, watches, necklaces, and other jewelry.

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2. Wear protective clothing when necessary and launder it periodically to keep clean.
3. Keep hair away from moving parts. Extremely long hair is a safety hazard—it must be tied back.

F. Tools and Equipment

1. Secure approval from your instructor for all work that you plan to do.
2. There should be absolutely no horseplay or running in the laboratory or class area.
3. Use traffic lanes, staying clear of safety zones unless you are the one operating equipment.
4. Learn procedures to follow in case of fire or accidents
    a. Discuss evacuation plan
    b. Discuss fire triangle (TM-8)
    c. Discuss types of fire extinguishers and their use (TM-9)
5. Follow all instructions and rules.

G. Special hazards

1. Gasoline

No smoking or open flames around gasoline.
Have adequate ventilation.
Wipe up spilled gasoline immediately.
Put the shop towels in a designated fire-proof container.
Store gasoline in an approved container, never in a glass jar or plastic jug.
Have fire extinguishers readily available.

2. Carbon monoxide

Colorless, odorless, and tasteless, it kills quickly.
Three minutes in an enclosed area with a running engine can be fatal.
Symptoms: Headache, weariness, dizziness, nausea, rapid breathing. In areas of high CO concentration the symptoms will be euphoria (everything wonderful, I feel great!), unconsciousness, death.

Operate vehicle engines with adequate ventilation and exhaust pipe vent tubes in place.
Remember — Be aware! Be alert! your attention to shop safety protects both you and others.

3. Batteries
    a. Heavy and awkward. If dropped they can crush hands or feet.
    b. Filled with highly corrosive acid. If spilled or splashed it can badly burn eyes and skin.

c. Batteries give off hydrogen gas if ignited. This will blow the top off of the battery, spraying acid everywhere!!

Wear acid proof gloves and eye protection when handling batteries.

SUGGESTED EMERGENCY ACTION FOR THE VOCATION TEACHER*

Be prepared! Think through what you will do in the event of injury before the emergency occurs. Discuss emergency procedures with your vocational administrator and principal. Arrange communications, first aid, transportation, and other details **before** an accident occurs.

If serious injury occurs, immediately take the following steps:

1. Have someone **notify** the principal and/or vocational administrator.
2. Do not leave class **unattended**.
3. First aid, if needed, should be administered only by a qualified person.
4. Notify parents. They should contact the family doctor.
5. If unable to reach parents, contact family doctor.
6. If above fails, call local doctor or hospital.
7. Contact parents as soon as possible.
8. To stop or check severe bleeding, use an antiseptic compress. Do not use a tourniquet unless trained to do so.
9. Do not move the injured person if bone fracture is likely.
10. Keep the injured person warm.
11. File a completed accident report and submit a copy to the principal, department head and/or vocational administrator.

* This procedure should be approved by the local administration before utilization.

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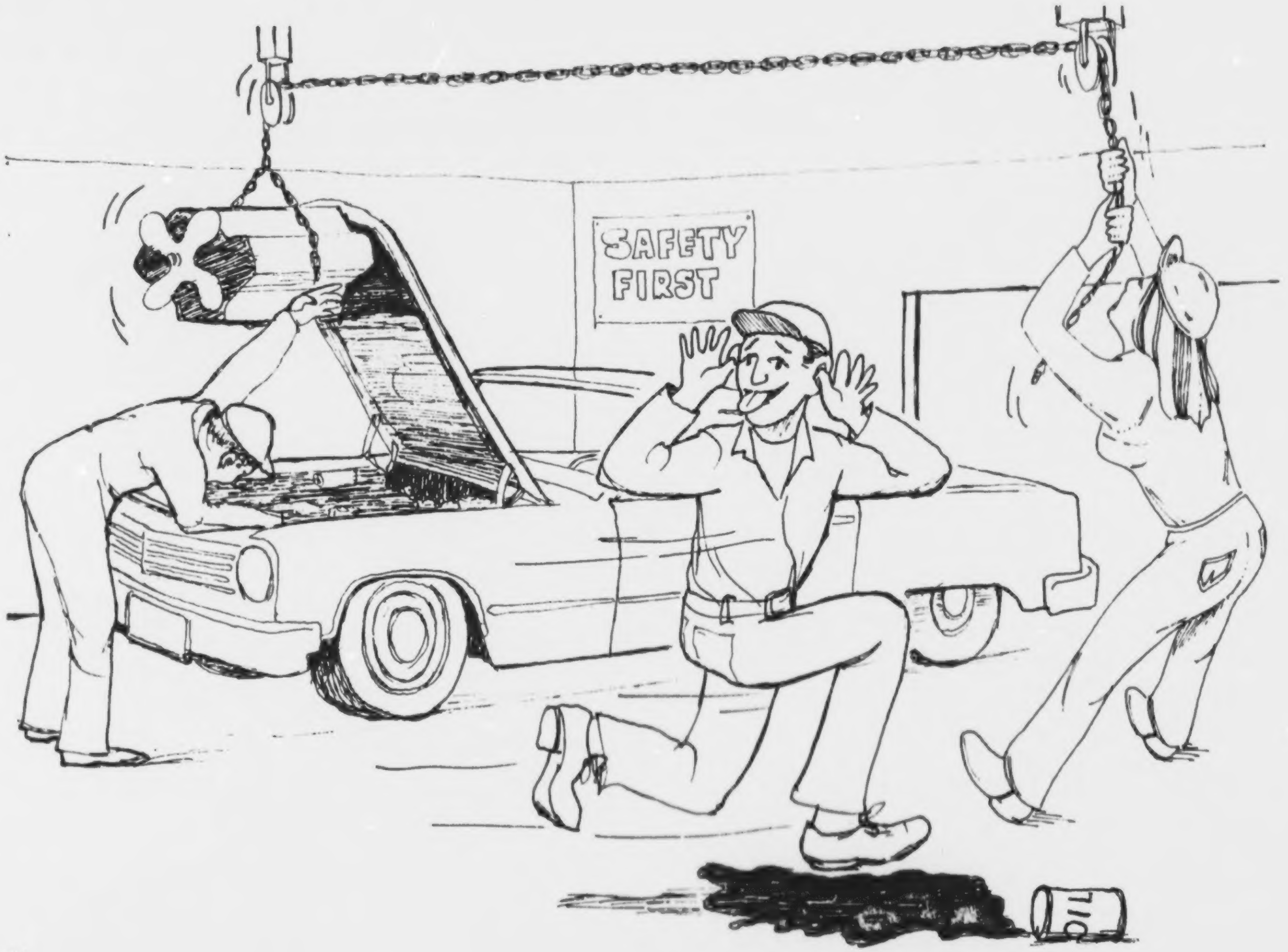
Horseplay in the Shop


SAFETY FIRST
OIL

TM-1

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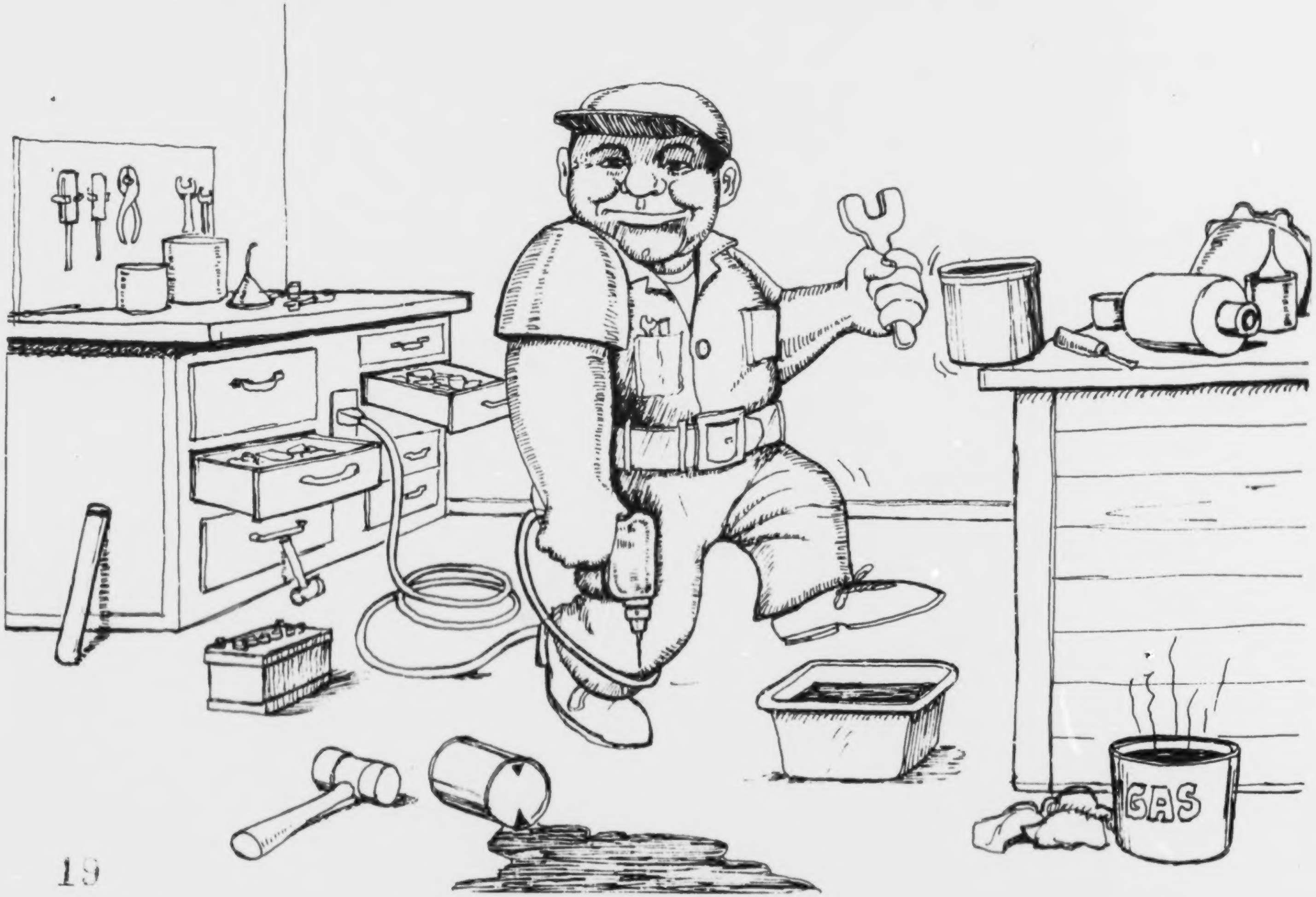
Recognize Unsafe Conditions



TM-2

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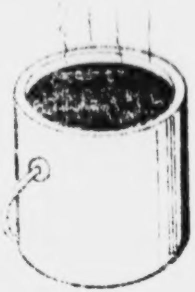
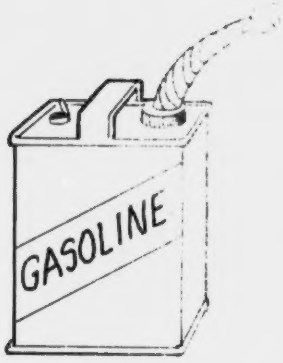
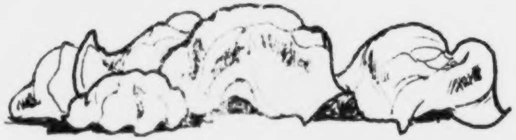
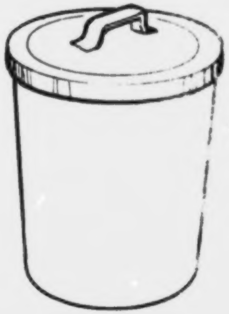
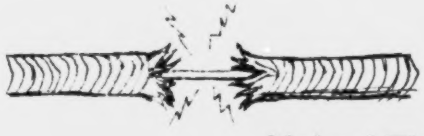
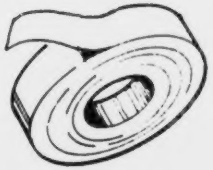
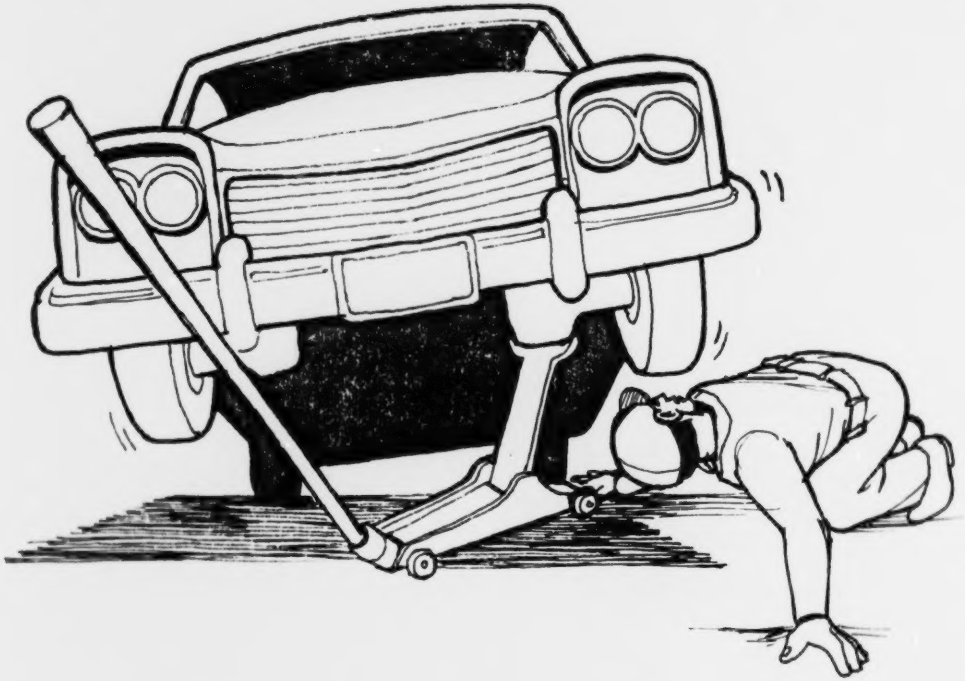
Fire Prevention

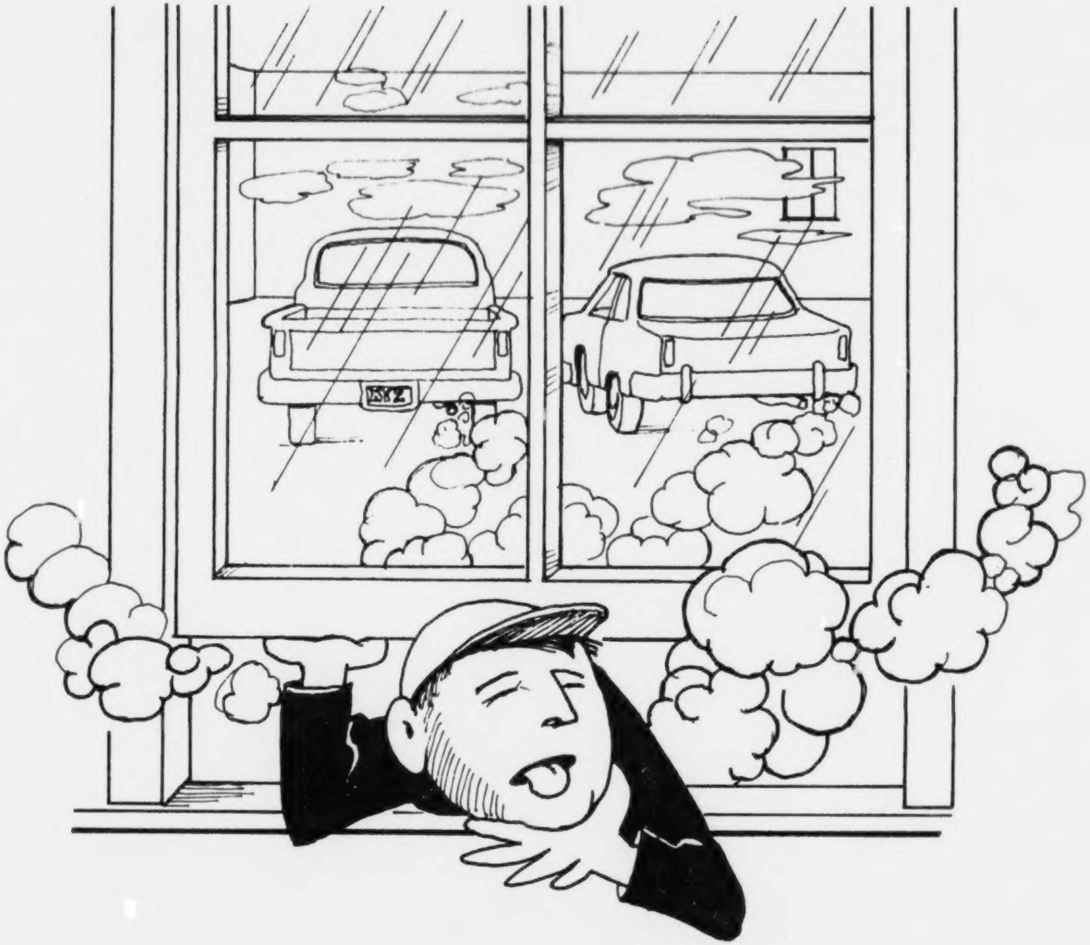
Dangerous Conditions	Remedies
 Open Can of Gasoline (Causes Explosions)	 Approved Safety Can
 Greasy Rags and Waste (Cause Spontaneous Combustion)	 Covered Metal Container
 Naked Electrical Wire (Causes Electrical Fires)	 Insulating Tapes

Lifting and Blocking



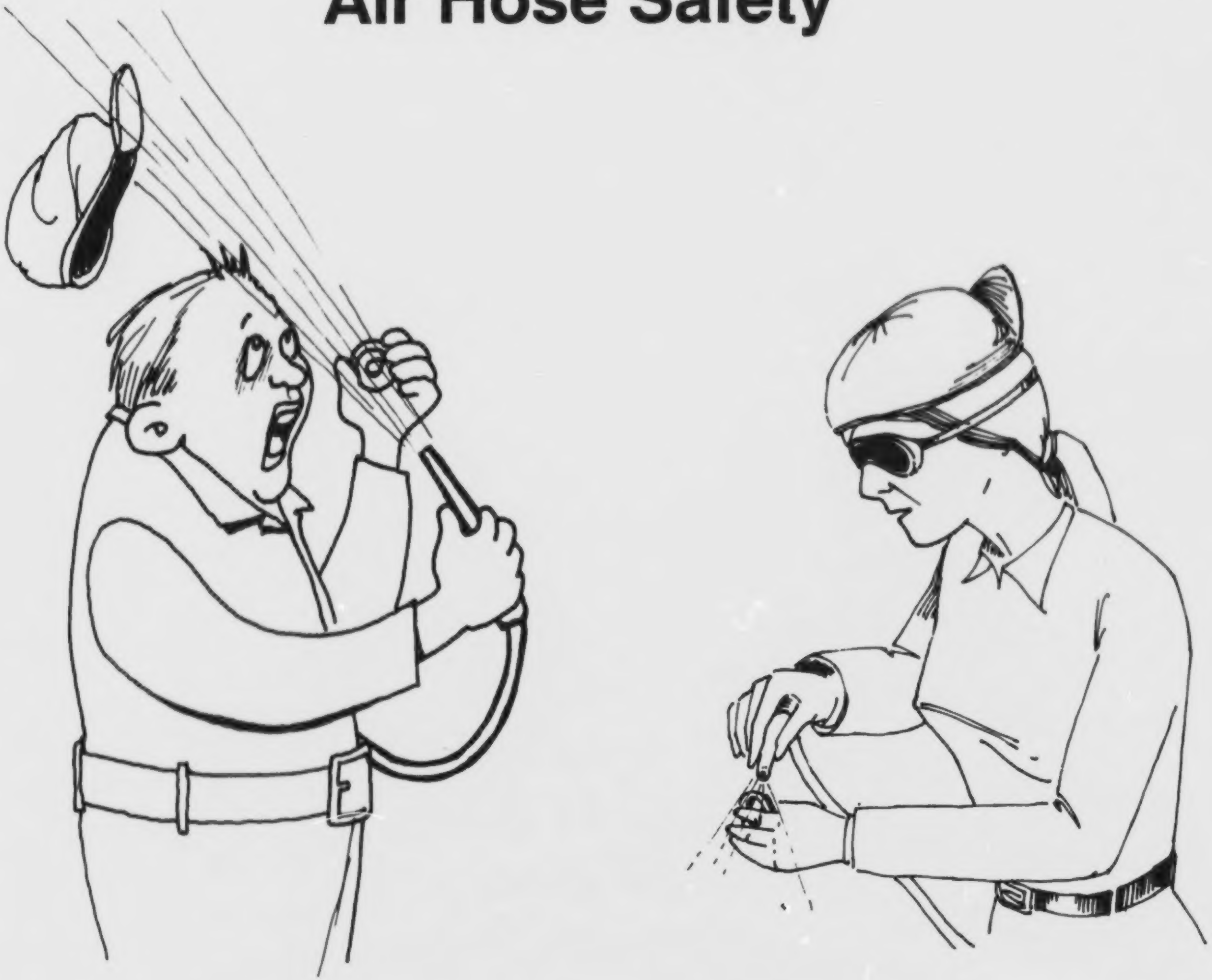
Always block the wheels and use jackstands

Proper Ventilation

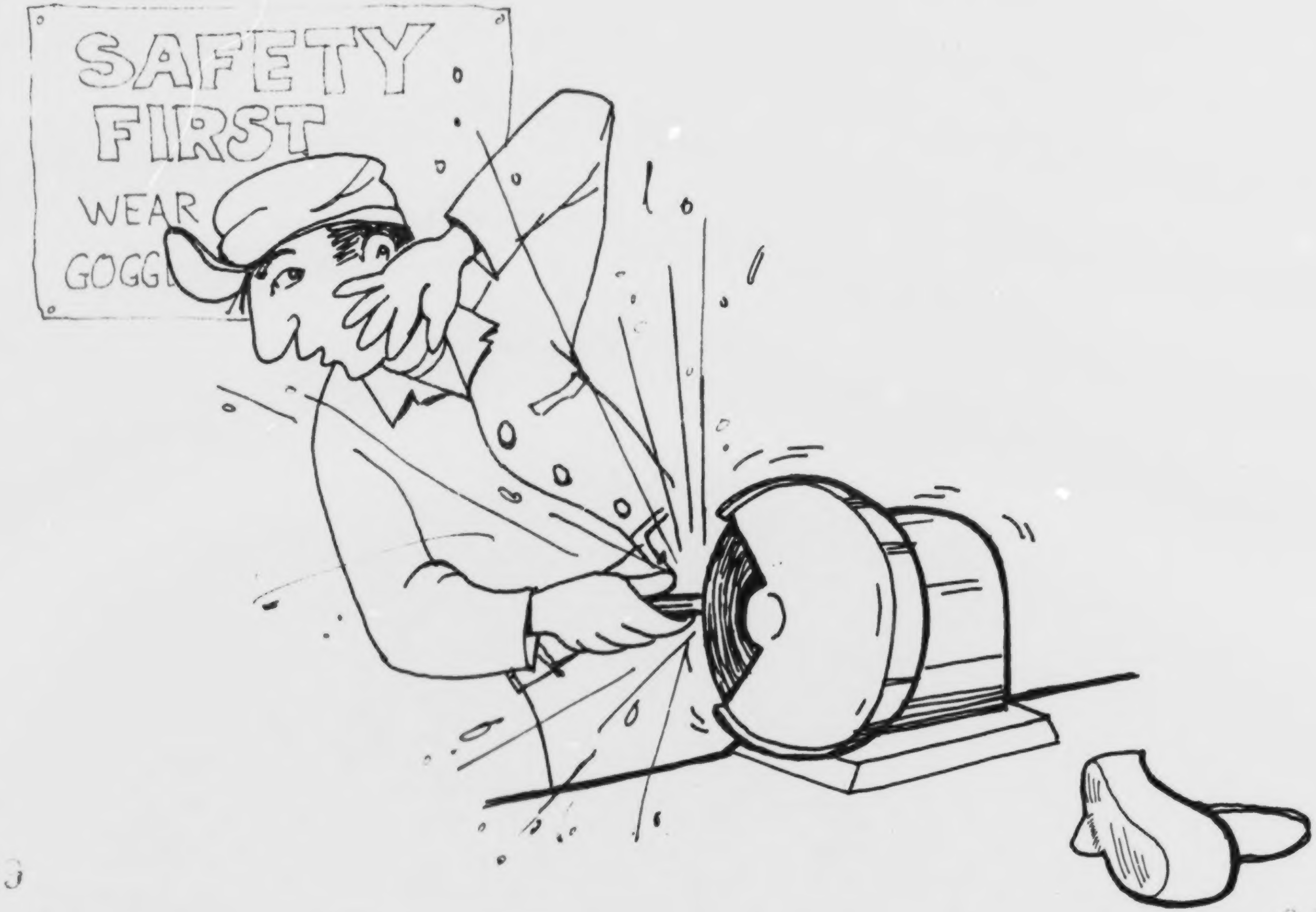


TM-5

Air Hose Safety



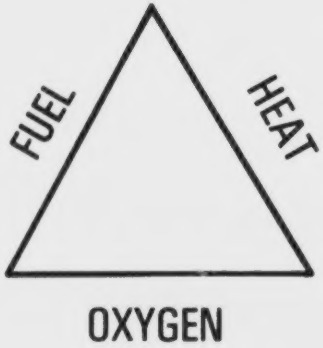
Eye and Face Protection


SAFETY
FIRST
WEAR
GOGG

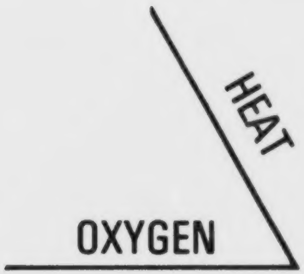
TM-7

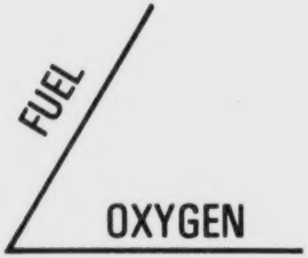
The Fire Triangle

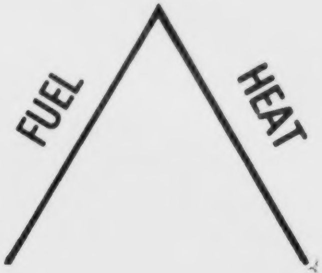
To produce fire, three things must be present at the same time.


FUEL
HEAT
OXYGEN

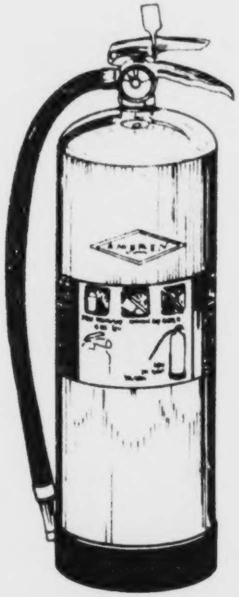
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.

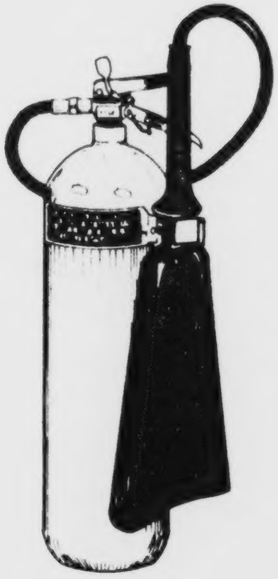

HEAT
OXYGEN

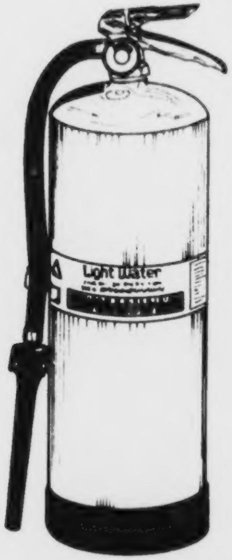

FUEL
OXYGEN

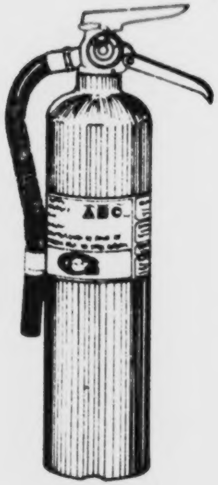


Types of Fire Extinguishers

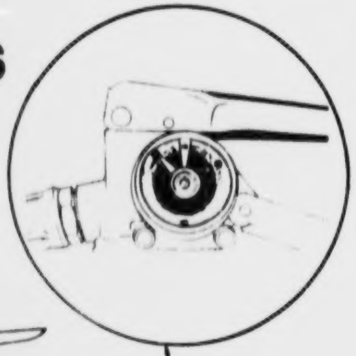

Pressurized Water


Carbon Dioxide CO_2


Light Water
Foam



Dry Chemical


Pressure Gauge

TM-9

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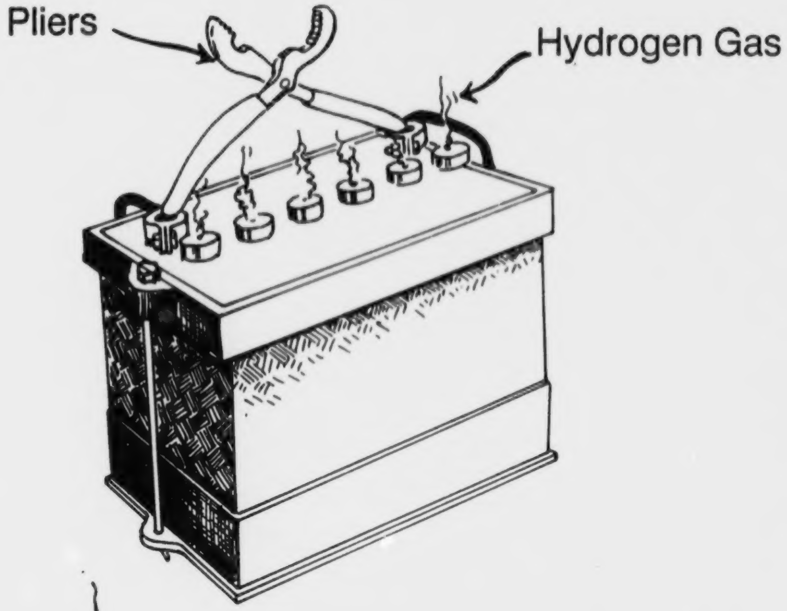
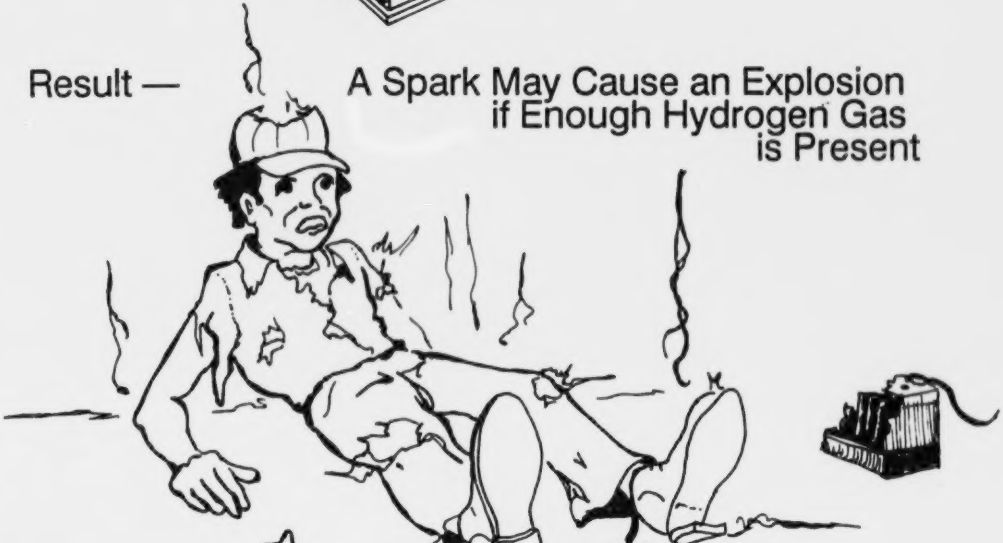
Proper Handling of Batteries

Do not Arc Terminals to Test — Or to Cause a Spark


Pliers
Hydrogen Gas

Result — A Spark May Cause an Explosion if Enough Hydrogen Gas is Present



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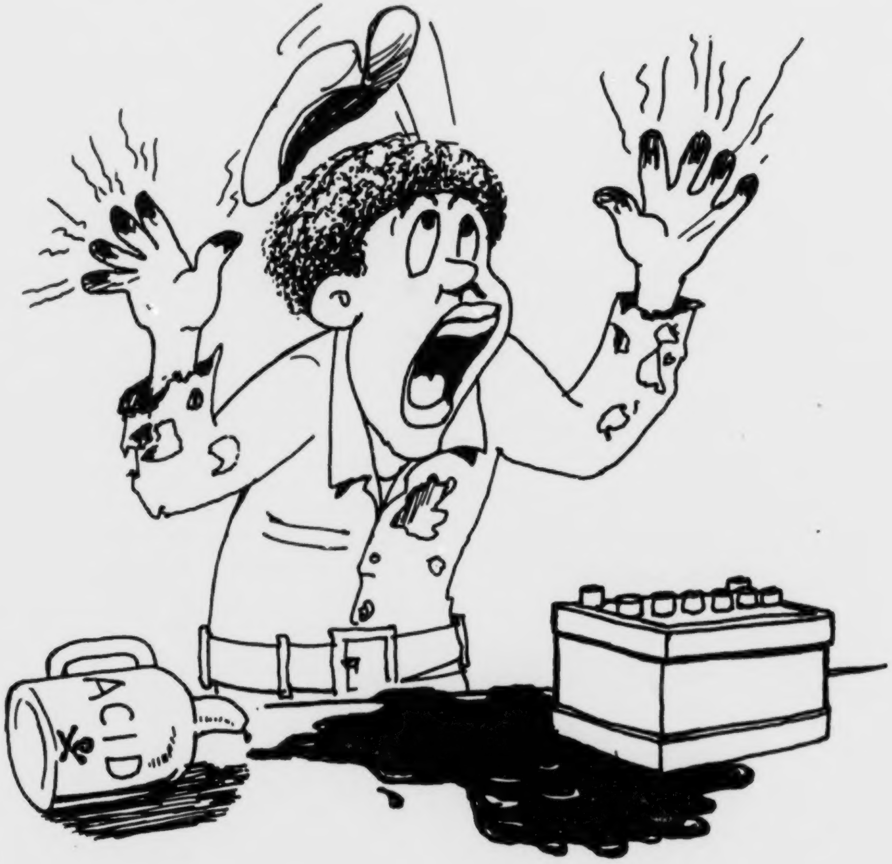
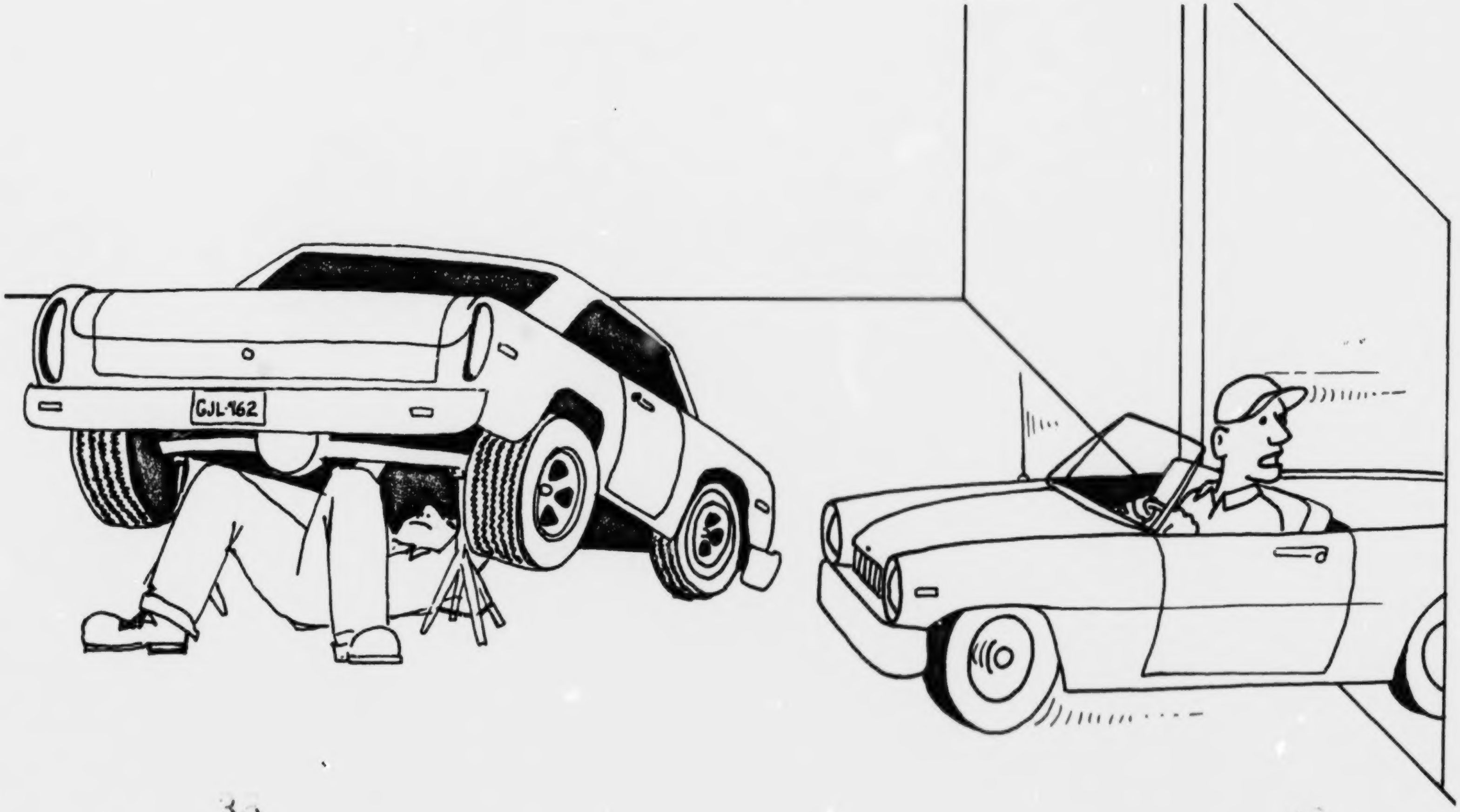
Acids



TM-11

Driving in the Shop



II-1-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Automotive Shop Safety

TOPIC: Safety

DIRECTIONS: Answer questions on automotive shop safety in space provided and complete each question.

1. Define the following terms:

   Safety:

   Personal safety:

   Group safety:

2. Select the proper safety attitudes for an automotive shop by circling the letter in front of each.

   a. Take your safety attitudes with you to every automotive shop.
   b. Do not be thoughtless because this causes most accidents.
   c. Guard against accidents even when you are the only one working.
   d. Visit others in the shop while working because two people can be more alert to accidents.

3. Determine the ways personal safety affects the individual by underlining the correct answer in each statement.
   a. Personal safety involves protecting (machinery, yourself) from injury caused by your own or others' actions.
   b. Personal safety involves being aware of (unsafe, safe) conditions and practices.
   c. Group safety involves (protecting, staying away from) others by practicing safety.

4. List four causes of accidents.
   a.
   b.
   c.
   d.

5. Decide which clothing rules are correct for the automotive shop by answering **true** or **false** to each of the following:

_____a. Long, loose hair can be worn in all shop situations.

_____b. Fire extinguishers should be easily located, and close at hand.

_____c. If you think you know how to operate a piece of equipment, you don't need to ask the instructor first.

_____d. Wearing safety glasses is not necessary in automotive shops.

6. Determine the correct safety rules for hand tools by answering **true** or **false** for each of the following:

_____a. Hand tools are small, easily concealed, and never dangerous.

_____b. Proper use and care can make your job easier as well as safer.

_____c. Tools should be thrown or tossed to the tool clerk to speed clean-up.

_____d. Pull on wrenches, but never push.

_____e. When leaving tools on the floor, put them in neat piles.

_____f. Carry tools with points up so you will not punch holes in your clothes or legs.

_____g. Repair loose handles at the end of the day so time will not be wasted during work.

41

_____h. Use hammers and other striking tools carefully.

_____i. Wrenches should fit loosely so they may be quickly removed.

7. Identify the correct safety rules involving the use of power tools by answering **True** or **False** to each of the following:

_____a. Always wear eye protection.

_____b. Wear proper clothing.

_____c. Don't tighten abrasive stones because they will crack.

_____d. Power tools should not reach full RPM because they will burn up.

_____e. Keep the grinding tool rest as close as possible to the grinding wheel.

_____f. Stand directly in front of the grinder while grinding.

_____g. Be aware of others around you.

_____h. Wipe up spills promptly.

_____i. Make adjustments on tools before unplugging the cord.

_____j. Never use power tools while wearing wet shoes or standing in water.

_____k. Leave stock loose while drilling.

_____l. Alert others when hot materials are lying around.

8. Point out the correct use of jack stands by circling the correct answer for each of the following:

   a. Use (a jack only, a jack and jack stands) when working on an automobile.

   b. Place stands (in a secure position, anywhere convenient) under the automobile.

   c. Use (gloves, adequate lighting) when placing stands under automobile.

   d. Release the jack (slowly, quickly), allowing the automobile to rest easily on the stands.

II-1-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Automotive Shop Safety

TOPIC: Organize a Safety Poster

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make effective safety posters.

TOOLS AND EQUIPMENT: 12-in. ruler, pencil, scissors, glue, scotch tape

MATERIALS: 20-in. x 30-in. poster board

GENERAL INSTRUCTIONS: Assemble materials, pictures or cutouts to prepare safety poster.

PROCEDURES AND/OR TASKS:

Prepare a safety poster on a large piece of cardboard or paper (approximately 20-in. x 30-in.). Illustrate accidents, prevention of accidents, safe use of materials or equipment on the poster. Create any unusual ideas that would help make safety a part of shop operations.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Automotive Shop Safety

TOPIC: Inspect the Shop for Safety Features

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to inspect an automotive shop correctly.

TOOLS AND EQUIPMENT: Pencil, clipboard, safety glasses

MATERIALS: Inspection forms

GENERAL INSTRUCTIONS: Check the shop for any unsafe features, using the list below. Rate each area by circling one of the following ratings:
S - Satisfactory
A - Acceptable (needs some attention)
U - Unsatisfactory (needs immediate attention)

PROCEDURES AND/OR TASKS: Make suggestions for correcting any areas rated "U" by writing them on the suggestion sheet.

1.	Machines, benches, and other equipment are arranged to permit good safety practices.	S	A	U
2.	Condition of aisles between equipment	S	A	U
3.	Condition of floors	S	A	U
4.	Condition of walls, windows, and ceilings	S	A	U

4

5. Sufficient lighting S A U
6. Ventilation S A U
7. Fire extinguishers are the proper type, in the proper place, and ready to use. S A U
8. Class members know how to use firefighting materials. S A U
9. Exits are properly marked. S A U
10. A fire escape plan is posted by each door. S A U
11. Tools are properly stored. S A U
12. Materials and scraps are properly stored. S A U
13. Dangerous or flammable materials are properly stored. S A U
14. Danger zones are properly marked and guarded. S A U
15. Color coding is correct on switches and moving parts. S A U
16. All switches are easily available to the operator. S A U
17. Cleaning brushes are available. S A U
18. Machines are in safe working condition. S A U
19. Tools are cleaned and sharpened, ready for use. S A U
20. All hoisting devices are in safe operating condition. S A U
21. All extension cords and other wiring are in good condition. S A U
22. All gas fittings and fixtures are in good shape. S A U
23. Goggles or protective shields are provided. S A U
24. Eye protection is being used properly. S A U
25. Safety rules are posted at each danger station. S A U

26. Safety posters are displayed. S A U

27. Safety posters have been changed regularly. S A U

28. Accident records are kept. S A U

29. A stocked first-aid cabinet is available. S A U

30. Someone has been designated to take care of first aid in case of an accident. S A U

II-1-JS-3

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT: Automotive Shop Safety

TOPIC: Safely Place a Car on Jack Stands

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to place a car on a jack stand correctly.

TOOLS AND EQUIPMENT:
Two-ton hydraulic jack
Four jack stands
Automobile
Safety glasses

MATERIALS: N/A

GENERAL INSTRUCTIONS: When placing jack or jack stand under the car, use proper lighting. Place the stands securely so they will not damage any part of the car or fall on the mechanic.

PROCEDURES AND/OR TASKS:

1. Place car in gear (park) and apply parking brake.
   Note: *Raise the front end first. The locked rear wheels keep the car from rolling. The rear wheels are raised last and lowered first.*

2. Place floor jack under front end of car in a safe, stable place. The front crossmember or a reinforced lifting point is best. If neither of these is available, get the instructor.

3. Raise car the desired height.

4. Place jack stands (2) in proper location.

   Demonstrate proper location:
      Ladder type frame (large U.S cars)
      Semi-monocoque (compact, sub-compact)

5. Have instructor check placement of jack stands.

6. Release jack slowly, allowing front of car to rest on jack stands.

7. Follow same procedure at rear of car.

      Place jack under:
      Differential carrier
      Rear axle tube (Front wheel drive)
      Rear A-arm anchor (IRS)

   If car is front wheel drive, have instructor check placement of floor jack **before** lifting.

8. Place jack stands under rear support points, and have instructor check your work.

9. Lower the vehicle slowly onto the jack stands.

10. Remove the floor jack and call the instructor.

11. Remove jack stands, reversing steps 1 through 10.

    Lower rear wheels first.

12. Replace tools and equipment.

13. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Engine Principles

TOPIC: Engine Parts and Operation of Engines

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to define the major engine parts and discuss their relationship to one another.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to discuss four cycle engines and the relation of the crankshaft, pistons, rods, valves, and bearings.

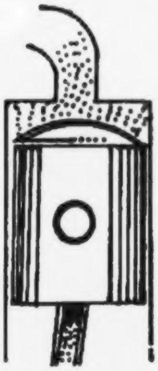
BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used when studying engine principles are reading concepts, oral and written communications, mathematics, and science.*

Types of Engines and How They Work

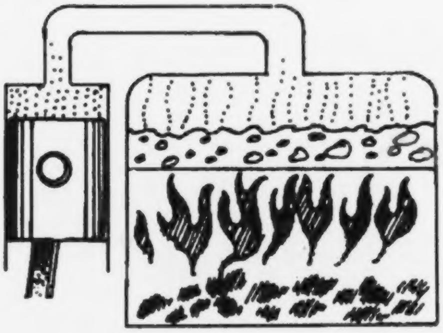
The purpose of the combustion engine is to convert chemical energy given off by burning fuel into a useful form. Modern engines have many parts, each being essential to the operation of the engine. The engine is a device that allows us to pour fuel in one end and get power from the other end.

The Combustion Engine

The **internal** combustion engine means to burn the fuel within. Gasoline indicates the type of fuel being burned. The engine indicates the device being used with which gasoline is burned.



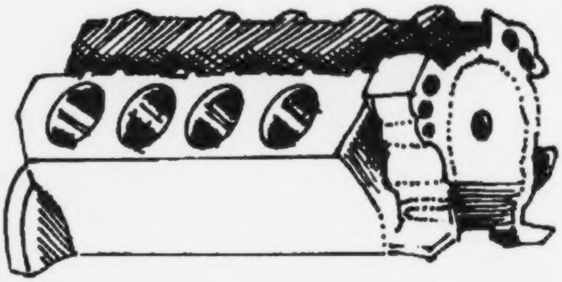
The **external** combustion engine is designed to accept the pressure of raw fuels being burned in another container and then forced into the engine.



Engine Parts and Their Purpose

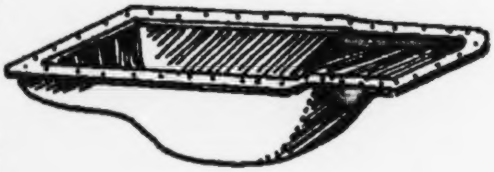
The **block** is the foundation for all parts of the engine, internal and external. It also supports the crankshaft and camshaft. The clutch housing also bolts to the block. The crankcase is part of the block.

Some of the older blocks are cast iron or aluminum poured into molds made of sand. Most of the blocks use a mold of metal and force molten aluminum or die cast material. Pressure cast blocks have several advantages. Blocks are free of voids or air bubbles. They have sharp corners and a high degree of accuracy is maintained using this casting method.



Crankcase/Oil Pan

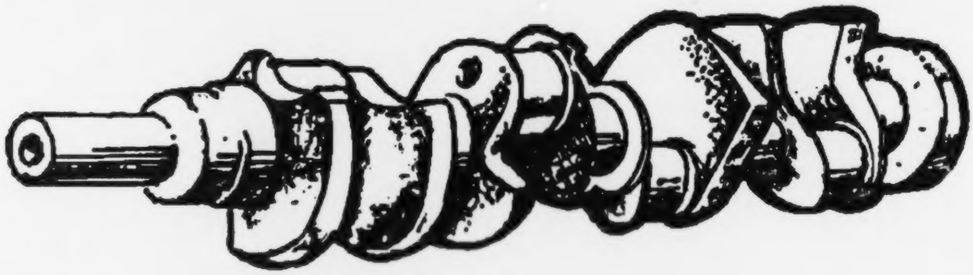
The oil pan attached to the bottom of the block forms the crankcase. They encase the webs on the crankshaft. Oil pans hold from 4 to 9 quarts of oil depending on the engine.



The crankcase also houses the oil pump. When the engine is running, the oil pump will send oil through the lubrication system to all the moving parts of the engine.

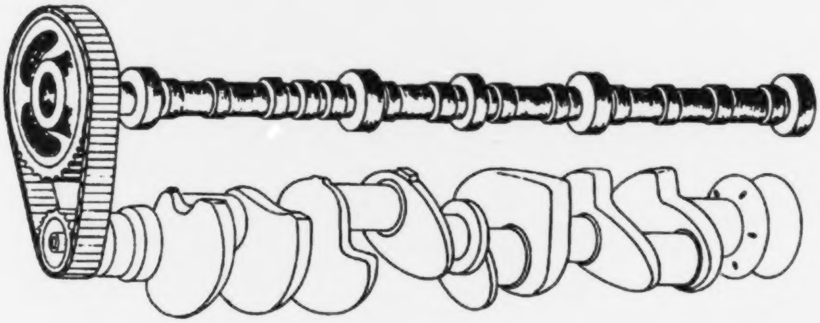
Crankshaft

The crankshaft provides the force that turns the wheels of the automobile. The connecting rods are attached to the rod journal on the crankshaft. Its function is to change reciprocating motion of pistons to rotary motion to drive the wheels. Crankshafts are made of alloy steel or cast iron. It has weights called webs used to balance the engine to keep it from vibrating.



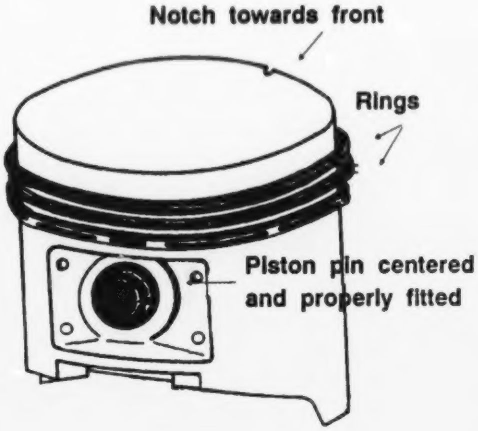
Camshaft

The camshaft is connected to the crankshaft by sprockets and a chain of a toothed belt, or sometimes by gears. The gear on the camshaft is twice as large as the gear on the crankshaft. This gear ratio of 1:2 causes the camshaft to turn at half the speed of the crankshaft. The crankshaft will turn two turns to every one turn of the camshaft. The cam changes rotary motion into linear or straight line motion.



In the engine the cam will open and close the intake and exhaust valves. Each cam has one lobe, and there are two cams for each cylinder, one for the intake valve and one for the exhaust valve. There is also a cam for the fuel pump, and a gear designed to operate the distributor.

Piston

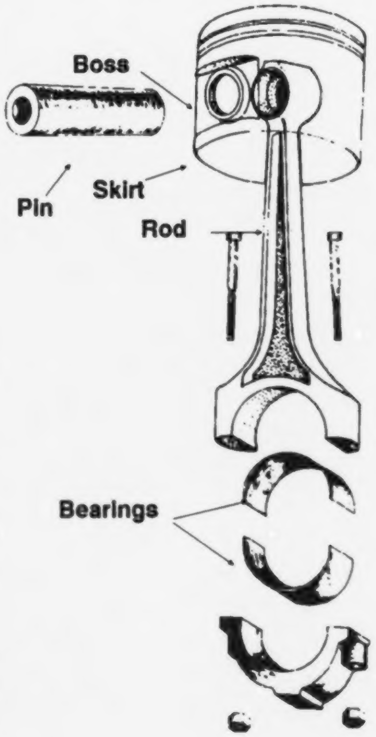


The piston has a round part closed on one end, and is literally a sliding plunger that moves up and down in the cylinder. The piston is connected to a connecting rod which is connected to the crankshaft. The piston must move up and down through the cylinder to produce a vacuum to draw fuel into the cylinder. The fuel is ignited on the upward motion of the piston while fuel mixture is compressed, this moves the piston back down through the cylinder. The piston will transmit the energy of the firing stroke to the crankshaft. The piston will then travel up through the cylinder, and exhaust the burned fuel.

Rings

The rings are flexible pieces of metal used to seal the piston to the cylinder wall during the power and compression stroke.

There are two types of rings—one is compression ring and the other is oil control ring. Most engines will use two compression rings and one oil ring. Others will use two compression rings and two oil rings. Diesel engines may have five or more rings.



Piston Pin/Boss/Skirt

The **piston pin** is the journal for the bearing in the small end of the connecting rod.

The **piston boss** is the part of the piston where the piston pin is inserted.

The **piston skirt** is the lower part of the piston. There are several type skirts. The split skirt has a slot cut in the skirt with a hole at the end of the slot to stop it from splitting. The T-slot is another way to control expansion. The partial skirt, has part of the skirt ground away, and also reduces piston weight and allows the piston to operate closer to the crankshaft.

The **connecting rods** connect the piston to the crankshaft. The upper end of the rod has a hole in it to install the piston pin. The lower end is split so the rod can be installed on the crankshaft journal. The upper and lower halves are bolted together. This transfers the force of the explosion from the piston to the crankshaft.

The connecting rods are drop forged to shape and then machined and are generally made of alloy steel. Rods for high speeds and high performance engines are made of aluminum.

The **bearing** is a replaceable load-bearing part. These parts cut down on friction and wear.

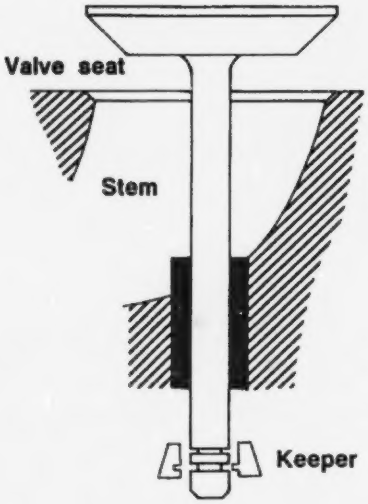
The main insert bearings are used on the crankshaft to hold it in place. The thrust bearing on the crankshaft controls the forward and backward movement of the shaft.

The **valve** is a device to start or stop the flow of the air-gas mixture. Valves also allow fuel to come into the cylinder and allow the burned fuel to exhaust out of the cylinder.

The **valve face** comes in contact with the valve seat.

The **keeper** is the small piece of metal used to secure the valve spring onto the valve.

The **valve seat** is the area on the engine with which the valve face comes in contact.



Parts of the Valve Train

One part of the valve train is the **camshaft.** It opens and closes the valves as the lobe makes a revolution, and takes one complete revolution of the cam lobe to every four strokes.

The **valve lifter** is installed between the valve stem and the cam lobe. The lifter slides up and down in a hole in the crank case that separates the valve stem from the camshaft.

The **push rod** is located between the valve lifter and the rocker arm. The push rod is hollow and feeds oil from the valve lifter to a contact area between the push rod and the rocker arm.

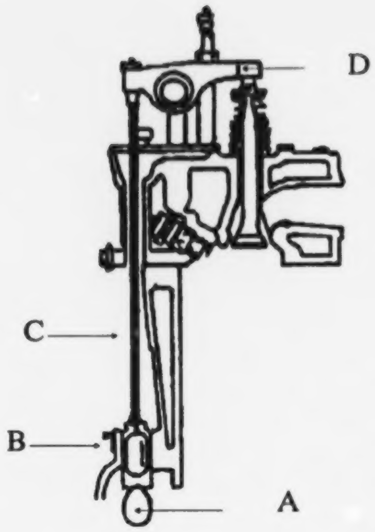
The **rocker arm** rocks on a shaft or pivots on a stud as the cam moves the push rod and causes the valve to open.

A. Camshaft

B. Lifter

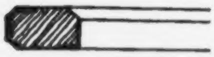
C. Push rod

D. Rocker arm

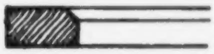


Types of Rings

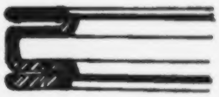
The **compression ring** is the upper ring or rings on a piston designed to hold the compression in the cylinder. It prevents blow-by.



The **wiper ring** scrapes the oil off the cylinder walls on the downstroke, and prevents oil from getting past the piston and into the combustion chamber.

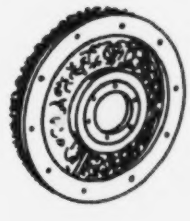


The **oil ring** applies oil to the cylinder wall on the upward stroke of the piston.



Purpose of the Flywheel

The **flywheel** is a rotating metal wheel attached to the crankshaft. It helps to balance and smooth the engine from power surges from the power strokes and serves as part of the clutch and engine cranking system.



The **flywheel gear** fits around the flywheel and is engaged by the motor drive to crank the engine.

Engine in Motion

Elements Necessary to Cause an Explosion in the Cylinder

Fire—The spark plug produces a spark to ignite fuel

Fuel—A combustible substance, usually gasoline

Air—Supports combustion of substance

Conditions Necessary to Run a Gasoline Engine

Some method of cranking the engine is used to start it turning.

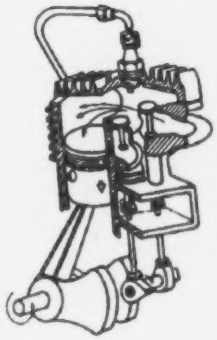
The correct amount of fuel and air is mixed.

The fuel and air mixture is pulled into the cylinder through the intake valve.

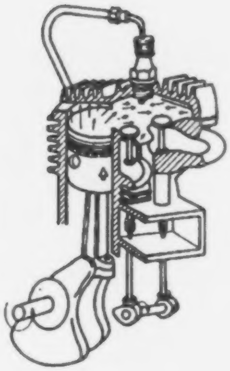
The spark plug fires near the top of the compression stroke, which explodes the gases and pushes the piston downward.

The Four-Stroke Cycles of a Gasoline Engine

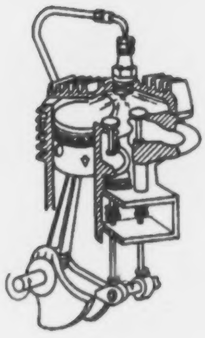
Intake stroke—As the piston moves downward, the intake valves open to be filled with the correct fuel air mixture.



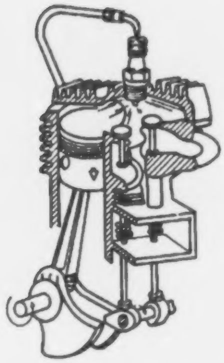
Compression stroke—As the piston moves upward, the intake valves close and the fuel-air mixture is compressed.



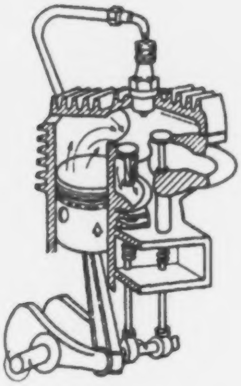
Ignition—This action is not considered a stroke, but an event that occurs, causing the fuel-air mixture to explode.



Power stroke—The piston begins a downward motion, being forced by expanding burning gases.



Exhaust stroke—The piston moves upward as the exhaust valve opens, allowing the burned gases to be forced from the cylinder.



Events in a Power Sequence

Note: *Follow number sequence on drawing.*

A. Explosion over piston

B. Piston drives rod.

C. Rod drives crankshaft

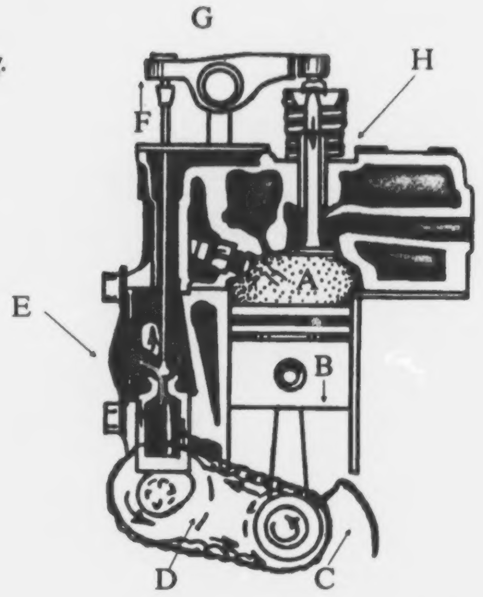
D. Crankshaft drives camshaft

E. Camshaft drives the lifter

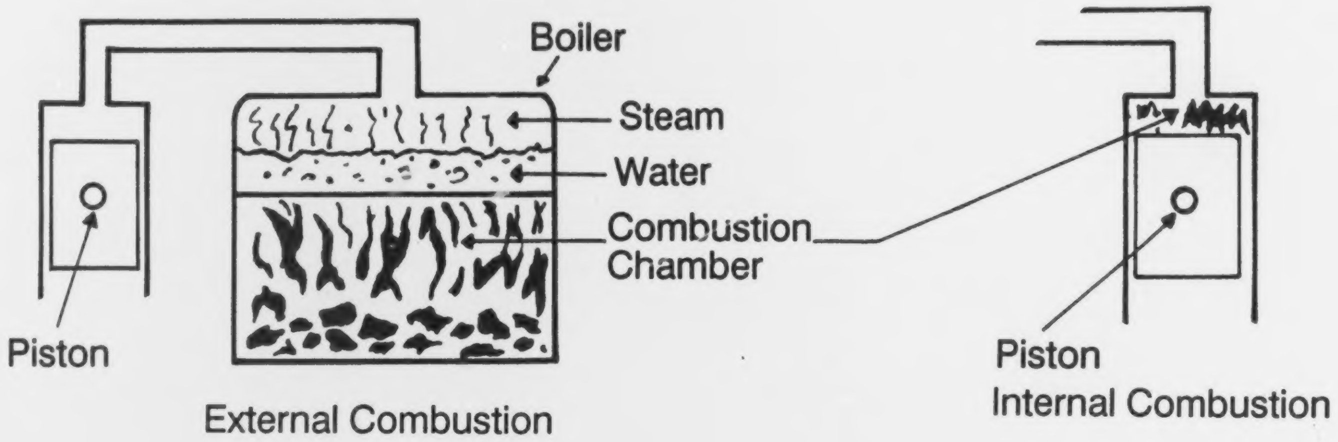
F. Lifter raises the push rod

G. Push rod drives the rocker arm

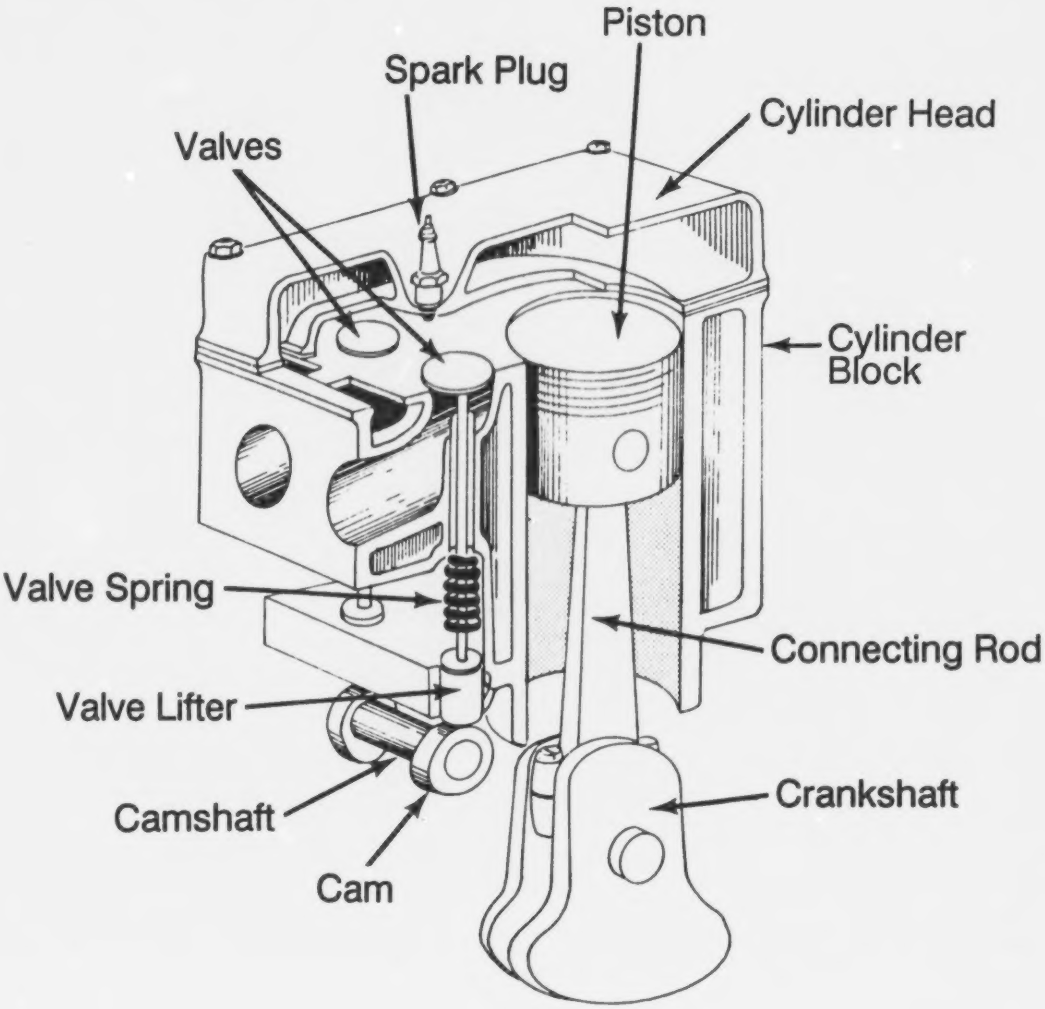
H. Rocker arm opens valve



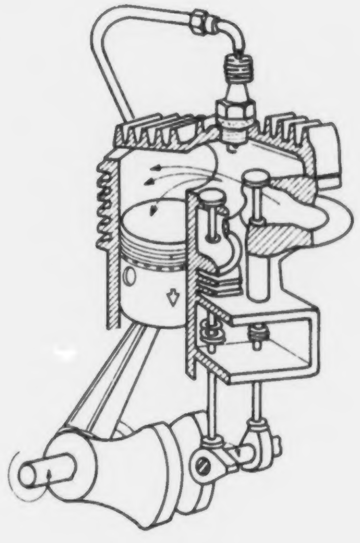
Internal and External Combustion


Boiler
Steam
Water
Combustion Chamber
Piston
External Combustion
Piston
Internal Combustion

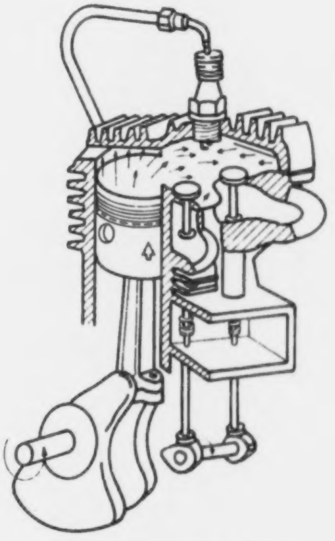
Basic Internal Combustion Engine Parts


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam

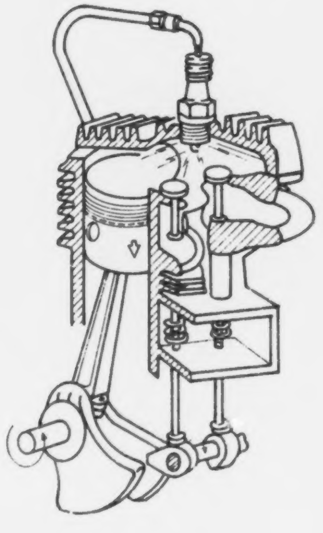
Four-Stroke Cycle



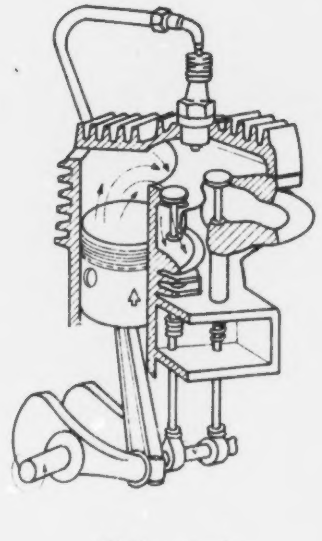
Intake



Compression



Power



Exhaust

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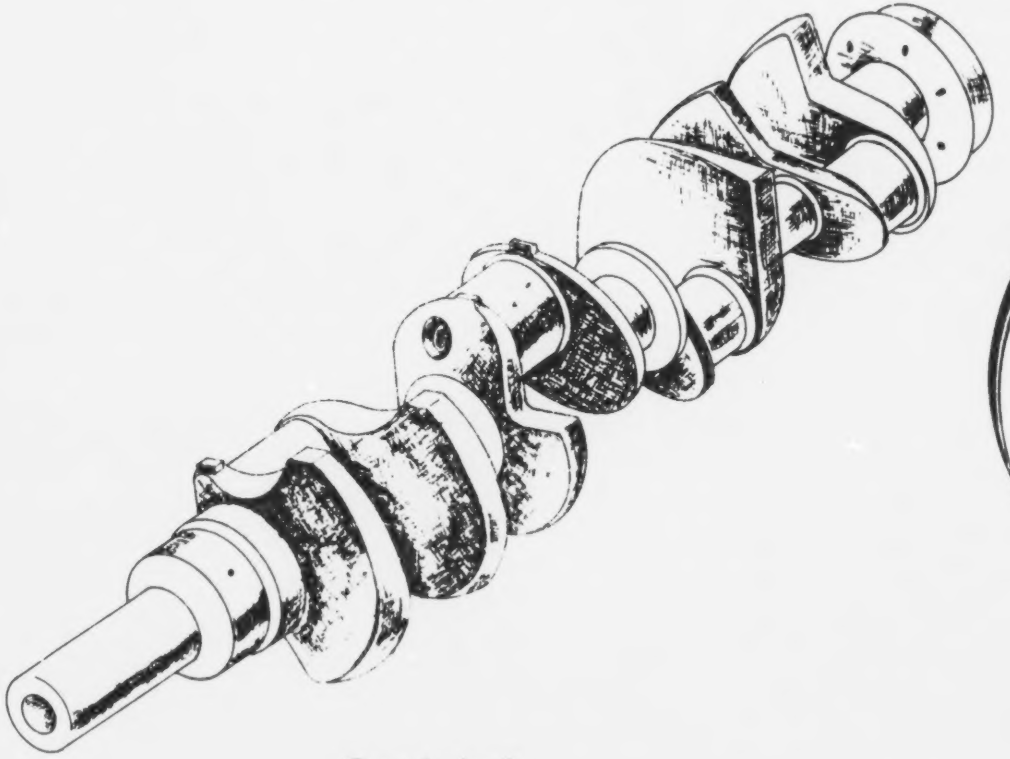
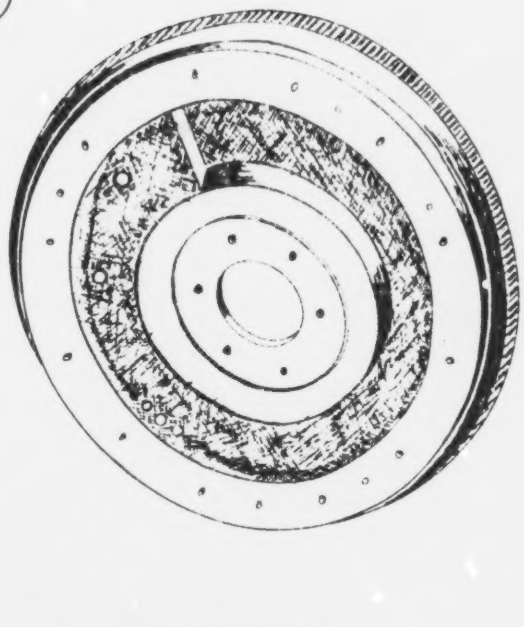
Crankshaft and Flywheel

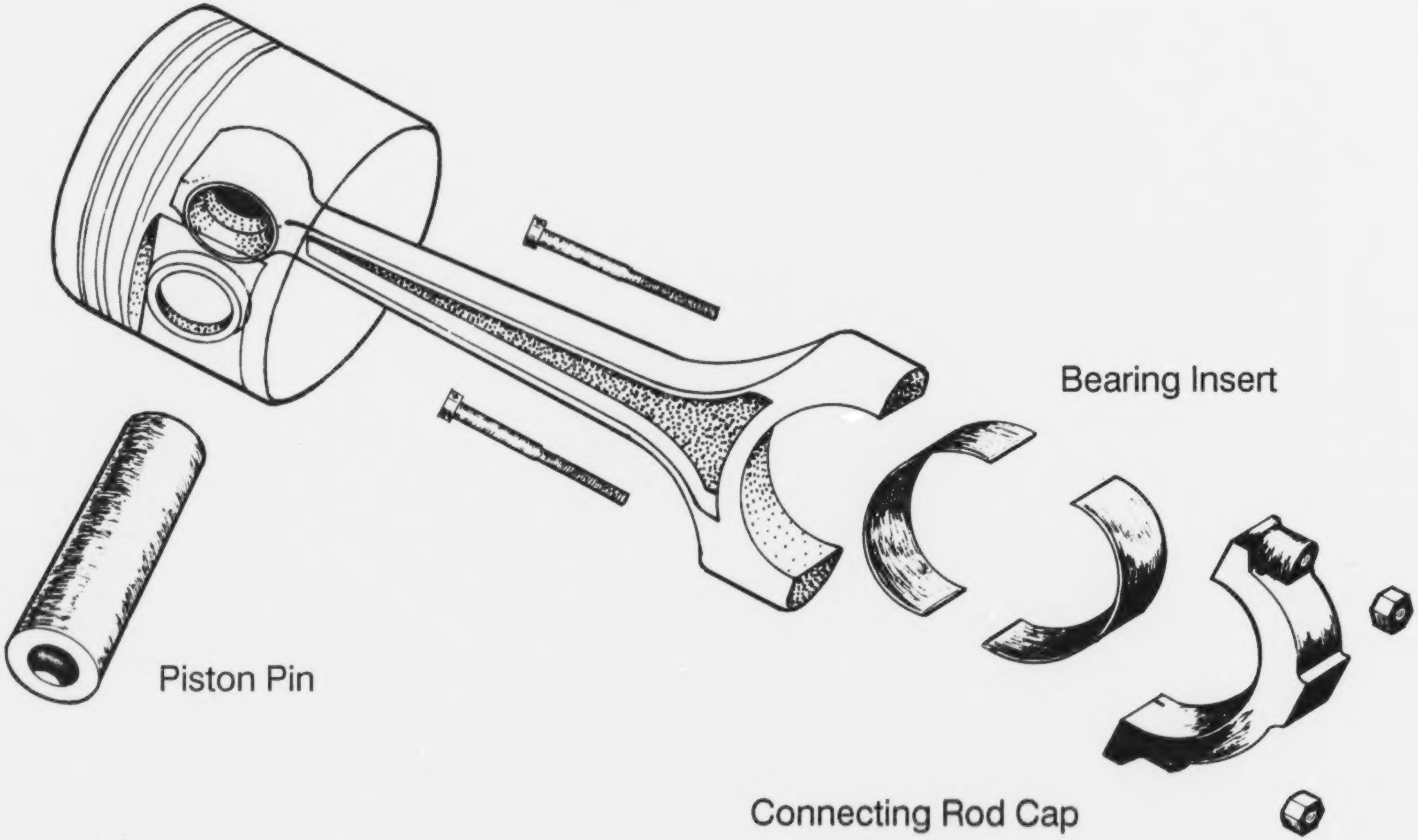


Crankshaft



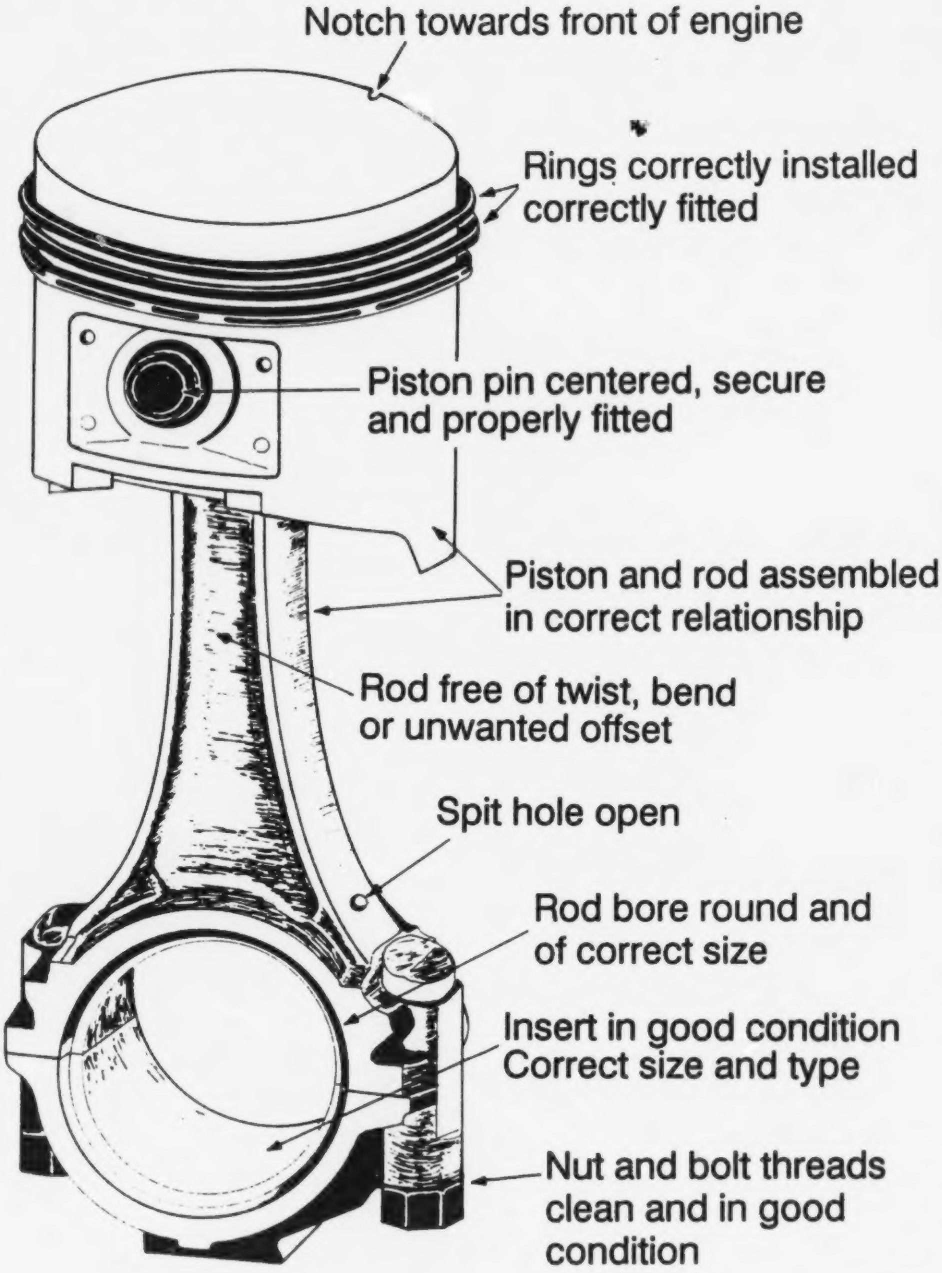
Flywheel

Rod

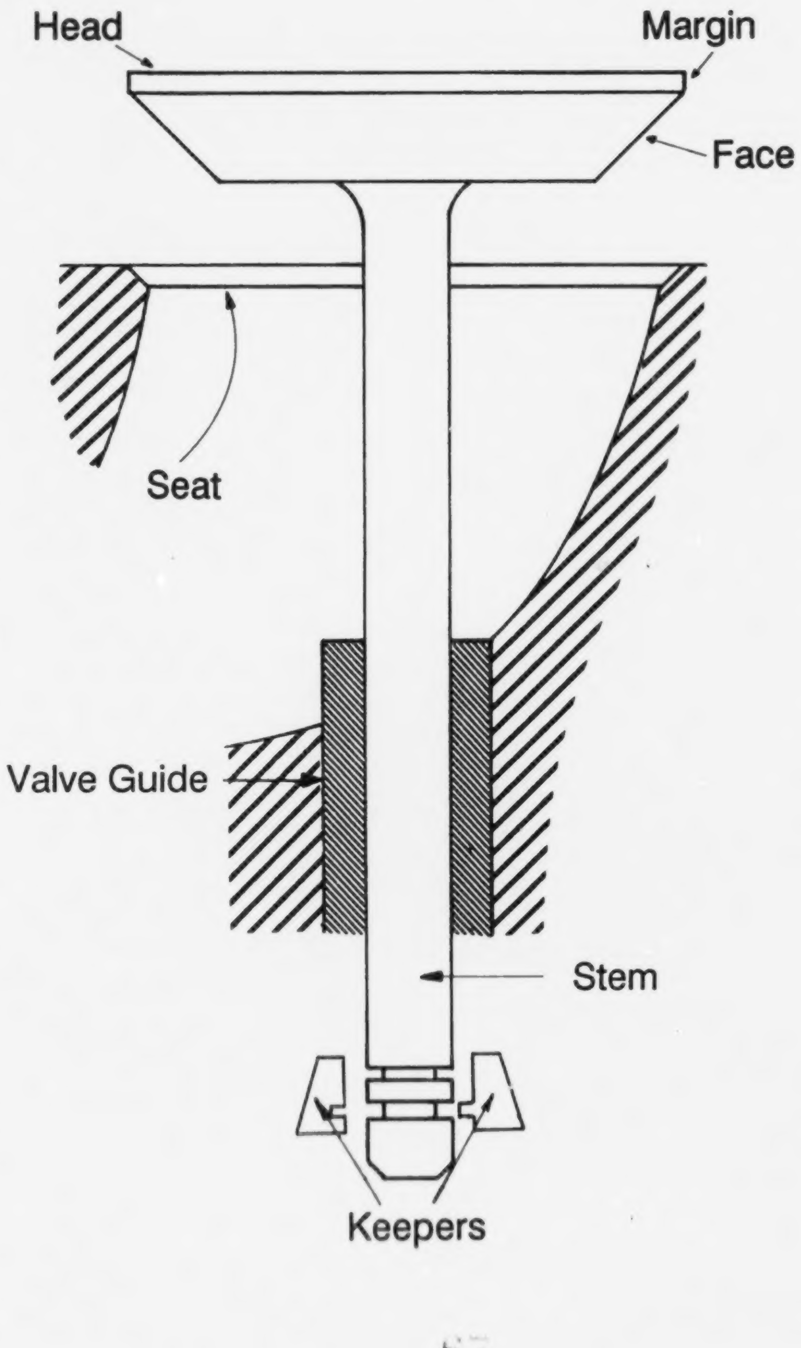

Bearing Insert
Piston Pin
Connecting Rod Cap

TM-5

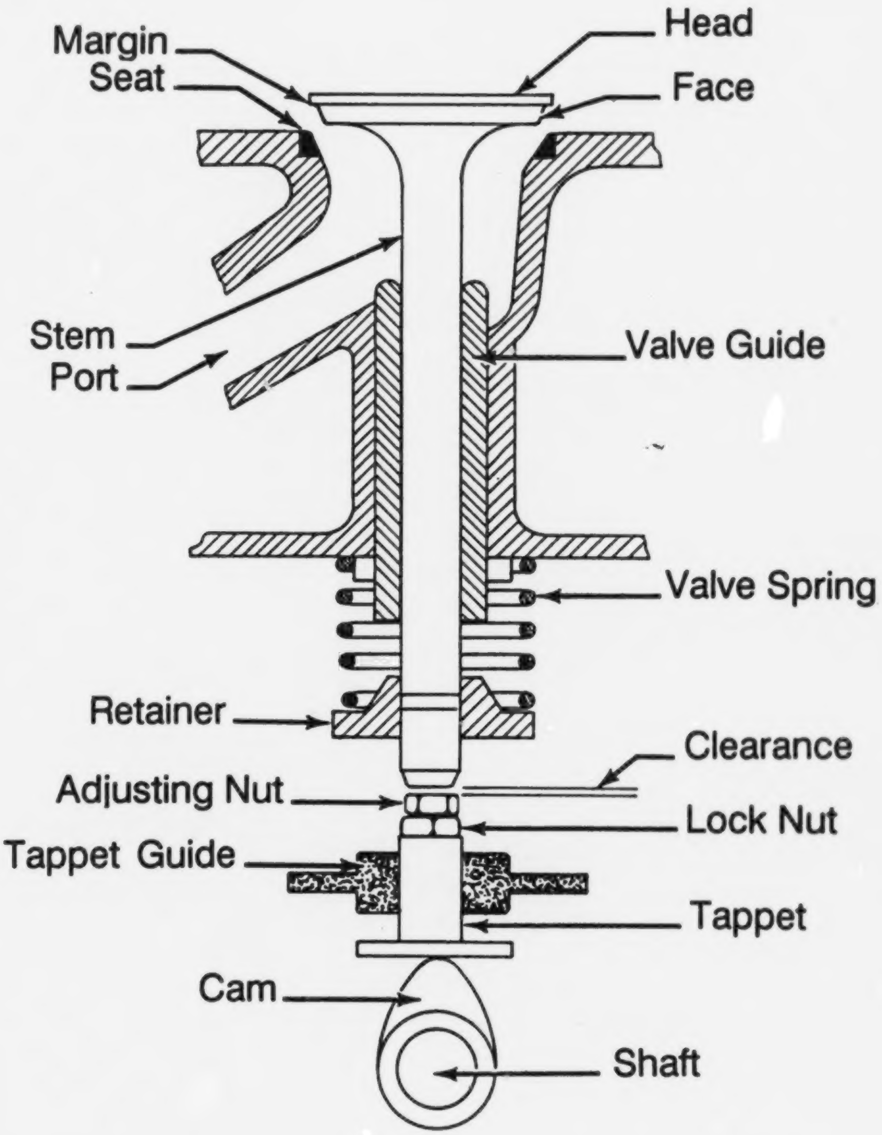
Piston and Rings


Notch towards front of engine
Rings correctly installed
correctly fitted
Piston pin centered, secure
and properly fitted
Piston and rod assembled
in correct relationship
Rod free of twist, bend
or unwanted offset
Spit hole open
Rod bore round and
of correct size
Insert in good condition
Correct size and type
Nut and bolt threads
clean and in good
condition

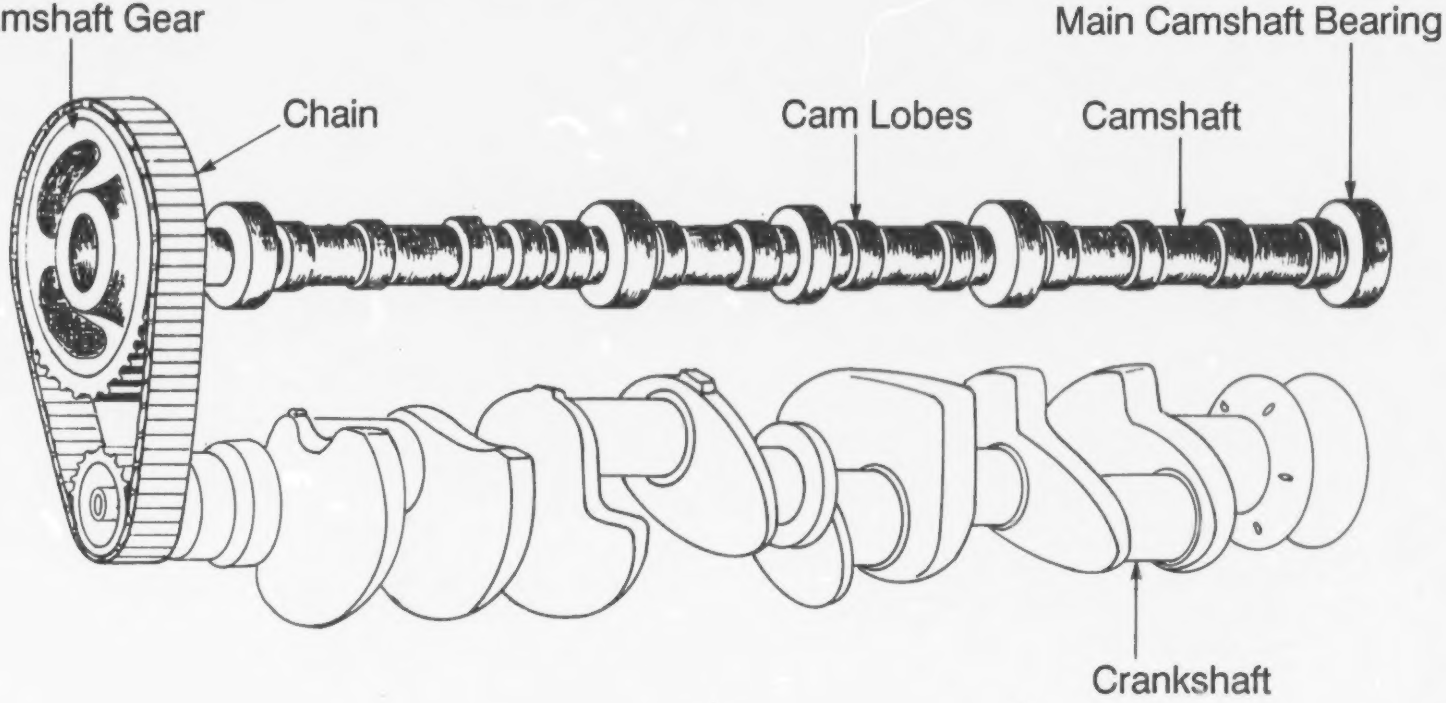
Valve


Head
Margin
Face
Seat
Valve Guide
Stem
Keepers

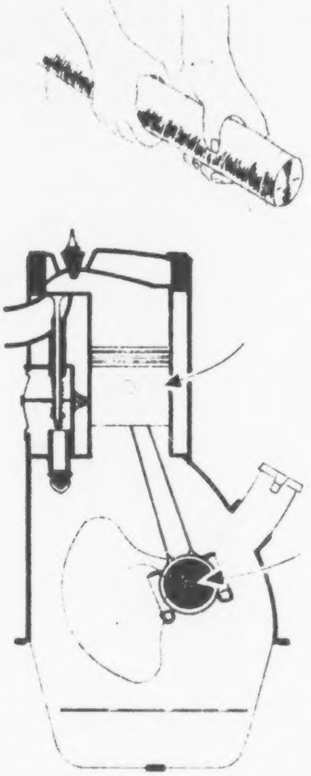
Valve Train


Margin
Seat
Head
Face
Stem
Port
Valve Guide
Valve Spring
Retainer
Clearance
Adjusting Nut
Lock Nut
Tappet Guide
Tappet
Cam
Shaft

Camshaft

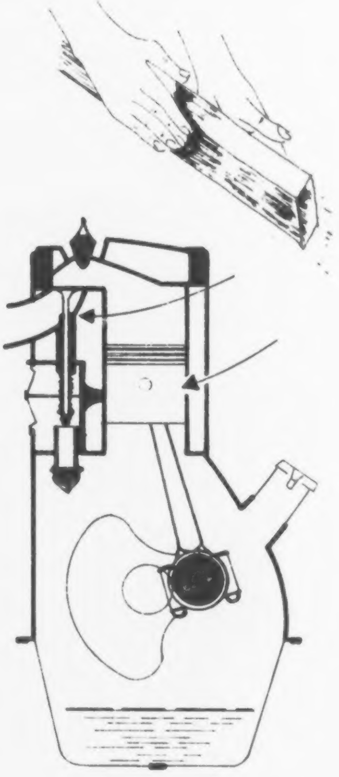

Camshaft Gear
Main Camshaft Bearing
Chain
Cam Lobes
Camshaft
Crankshaft

Bearing Types



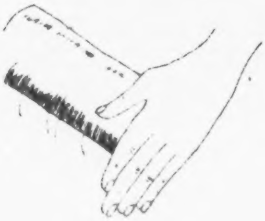
Journal

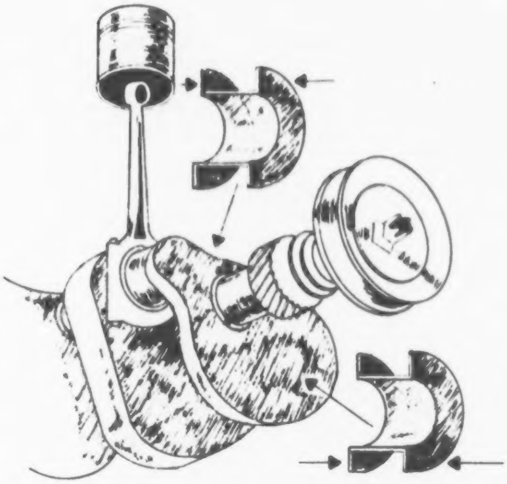
Bearing Types



Guide

Bearing Types





Thrust

II-2-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Engine Principles

TOPIC: Engine Parts and Operation of Engines

DIRECTIONS: Answer questions on engine principles in space provided and complete each question.

1. Explain the purpose of the combustion engine.

2. Point out the differences in the internal and external combustion engines.
   a. Internal combustion

   b. External combustion

3. Match the terms associated with the parts of the combustion engine with the proper definition by writing each number on the right in the correct blank on the left.

_____a. The lower part of the piston

_____b. The part of the piston through which the piston pin is inserted

_____c. The part of the valve that comes into contact with the valve seat

1. Piston boss
2. Valve face
3. Piston skirt

_____d. The housing within which the crankshaft and many other engine parts operate and are oiled

_____e. Area on the engine with which the valve face comes in contact

_____f. Pieces of metal used to secure the valve spring onto the valve

_____g. Connects a rod to the piston

_____h. Device used to start or stop the flow of the air-gas mixture

_____i. A replaceable load-carrying part

_____j. The shaft containing lobes or cams

_____k. The journal for a bearing in the small end of a connecting rod

_____l. A flexible piece of metal used to seal the piston with the cylinder walls during the power and compression strokes

_____m. A round part closed on one end

_____n. Main framework of the piston engine

_____o. A shaft connecting the piston to the crankshaft

_____p. The main shaft running through the engine

_____q. Cuts down on friction

_____r. Provides space to mount external parts

_____s. Installed in a cylinder hole

_____t. Allows fuel to come into the engine

_____u. Used to open the engine valves

4. Crankcase
5. Keepers
6. Piston pin
7. Valve seat
8. Camshaft
9. Valve
10. Bearing
11. Piston
12. Block
13. Connecting rod
14. Ring
15. Crankshaft

_____v. Transfers the force of the explosion from the piston to the crankshaft

_____w. Converts the up and down motion of the piston to usable rotary power

_____x. Houses all internal parts

_____y. Transfers force of explosion to a connecting rod

4. Arrange the events of a power sequence in order, beginning with explosion over piston.

_____a. Explosion over piston	
_____b.	1. Push rod drives the rocker arm
_____c.	2. Piston drives rod
_____d.	3. Rocker arm opens valve
_____e.	4. Camshaft drives the lifter
_____f.	5. Rod drives the crankshaft
_____g.	6. Lifter raises the push rod
_____h.	7. Crankshaft drives the camshaft

5. Determine the function of each type of ring used on the piston by placing the correct number to the left of each letter.

_____a. Compression ring	1. Seals the piston within the cylinder and prevents explosion "blow-by"
_____b. Wiper ring	2. Wipes the oil off the cylinder wall back into the oil pan on the downward movement of the piston
_____c. Oil ring	3. Applies oil to the cylinder wall on the upward stroke of the piston

6. Determine the functions of a flywheel by answering "yes" or "no" to each of the following statements.

_____a. The flywheel acts as a balance to smooth the engine.

_____b. The flywheel provides a gear to turn the water pump.

_____c. The flywheel provides a starter gear.

_____d. The flywheel acts as a centrifugal wheel to carry the engine to the next stroke.

_____e. The flywheel changes the direction of rotation to the transmission

7. Identify the three elements necessary to cause an explosion in the cylinder by placing a "√" mark beside the correct answers below.

_____a. water

_____b. fire

_____c. wind

_____d. air

_____e. fuel

8. Arrange the events necessary to start an engine in the proper order by numbering 1 through 4 for each of the following:

_____a. The correct amount of fuel and air mixes.

_____b. The spark fires near the top of the compression stroke, which explodes the gas and pushes the piston downward.

_____c. The fuel and air mixture is pulled into the cylinder through the intake valve.

_____d. The engine is cranked which starts it turning.

9. Match each of the strokes to the function of the four-stroke cycles of a gasoline engine by placing the correct number to the left of each answer.

_____a. As the piston moves downward, the intake valves open to allow the cylinder to be filled with the correct fuel-air mixture.

_____b. As the piston moves upward, both valves close, causing the fuel and air mixture to be compressed into a small area.

1. Compression
2. Intake
3. Exhaust

_____c. This action is not considered a stroke, but an event that occurs, causing the fuel-air mixture to explode.

_____d. The piston begins a downward motion, being forced by expanding burning gases.

_____e. The piston moves upward as the exhaust valve opens, allowing the burned gases to be forced from the cylinder.

4. Ignition
5. Power

10. Point out the function of each of the parts of the valve train by placing the appropriate number to the left of each letter.

_____a. Camshaft
_____b. Lifter
_____c. Push rod
_____d. Rocker arm

1. Pushes the valve open
2. Pushes the rocker arm
3. Raises the push rods
4. The lobes lift the hydraulic lifters

II-3-IS

STUDENT INFORMATION SHEET
MINOR AUTOMOBILE MAINTENANCE

UNIT: Fuel System Operation and Repair

TOPIC: Fuel System

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to discuss the operation of the fuel system and repair each of its components.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will understand parts of the fuel system.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with fuel systems operation and repair include mathematics, oral and written communications and reading concepts.*

Fuel System

The purpose of the fuel system is to store, transfer and mix fuel and air for feeding into the engine during operation. The fuel system must vary the proportions of air and fuel for different operating conditions. When the engine is cold, the air fuel mixture must be rich. This is because the fuel will not vaporize readily at low temperatures.

System Terms

Baffles—Metal plates separating the fuel tank into sections, yet will allow fuel to pass slowly between them

Sending unit—Measures the quantity of fuel in the fuel tank

Diaphragm—Made of thin layers of cloth bound together with a special compound that makes it airtight and resistant to petroleum products

Accelerate—To go from low speed to high speed

Fuel Tank

The fuel tank is usually located at the rear of the vehicle and is attached to the frame with metal straps. Although most tanks are constructed of thinwall stamped sheet metal, some tanks are made of heavy plastic. This material is lighter, resists denting, and doesn't rust.

The filler opening of the tank is connected by a flexible pipe to the fuel cap. A vent is incorporated in the filler opening to allow air to escape during fueling, and to allow for fuel expansion during hot weather.

Along the side, or top, of the tank, you will notice a circular metal cover about 5 in. in diameter. It is secured by screws, and has one or more electrical connectors. This plate houses the fuel sending unit, and on most fuel-injected cars, the electric fuel pump. The sending unit sends a signal to the fuel gauge to show fuel quantity.

Fuel Lines

The fuel lines are tubes connecting the tank, fuel pump, and carburetor. Most fuel lines are made of 5⁄16-in. steel tubing. (Shown on TM-1)

Fuel Pumps

The fuel pump delivers fuel from the tank to the carburetor. Mechanical fuel pumps operate by an eccentric (off-center section) on the engine camshaft. The mechanical fuel pump is mounted on the side of the cylinder block. The mechanical pump has a rocker arm with an end that rests on the camshaft eccentric. Some V-8 engines also use a push rod extending from the eccentric to the rocker arm. As the camshaft rotates, the eccentric causes the rocker to rock back and forth, which in turn causes the diaphragm to pull down and release. This causes the fuel to be pulled from the tank and forced to the carburetor under pressure. (Shown in TM-3)

Fuel Filters

Several materials have been used in attempts to find an ideal fuel filter, a fire screen, ceramic, treated paper, sintered bronze elements and inline and bowl-type filters. All fuel moving to the carburetor must pass through the cleaning element to remove dirt and water from the fuel. Special treated paper is widely used for cleaning elements. (Shown on TM-4)

These filters can be located in the tank at the fuel suction pickup, the fuel pump inlet, or between the pump and the carburetor.

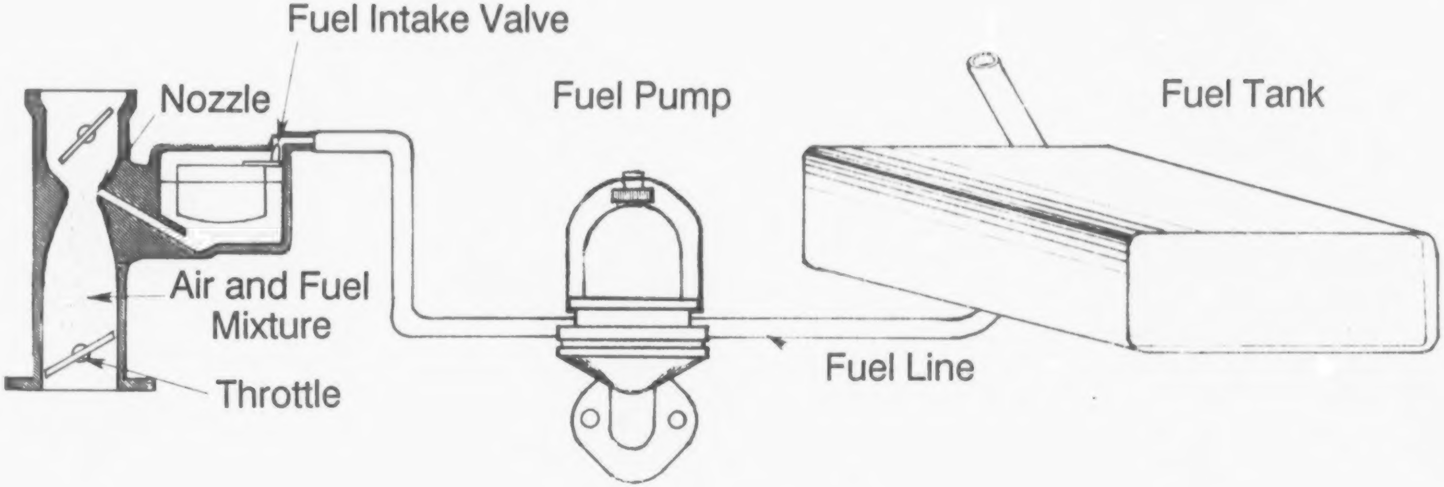
Carburetor

Carburetion is the process of mixing gasoline fuel with air so a combustible mixture is obtained. The mixture must be rich when starting acceleration and during high-speed operation. A leaner mixture is used for intermediate speeds with a warm engine. The carburetor mixes fuel and air at a ratio of 13 parts air to 1 part fuel. The fuel circuits or routes are idle circuit, high speed circuit, acceleration circuit, float system, and choke system. (Shown on TM-5)

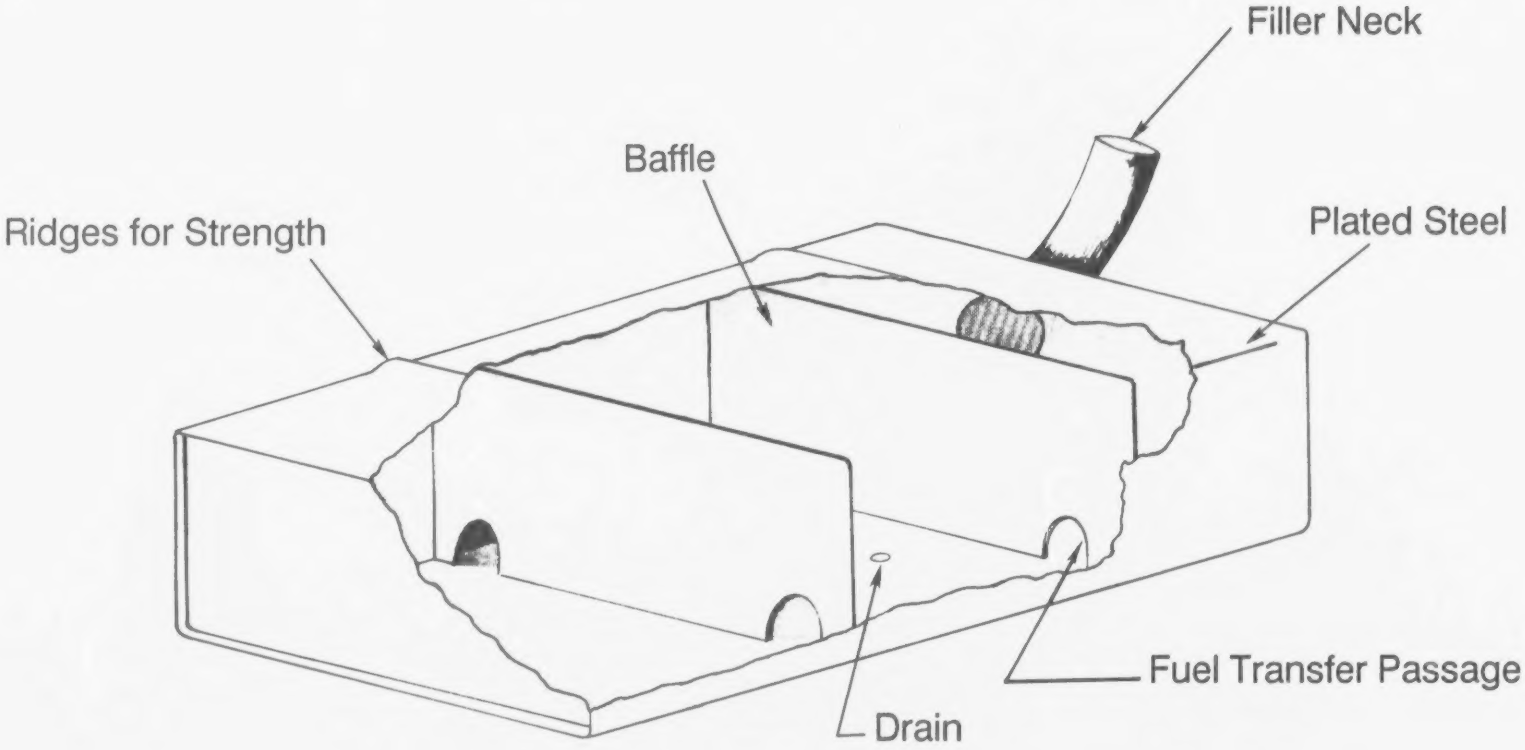
Air Filters

Air cleaners are essential. Air entering the carburetor should be clean, and a good air filter, properly serviced, will add to the life of the engine. Most air cleaners are made of paper, pleated accordion style. They should be cleaned or replaced quite often when used in dusty conditions, because a dirty filter will cause engines to use more fuel. These units are always located on top of the carburetor. (TM-6)

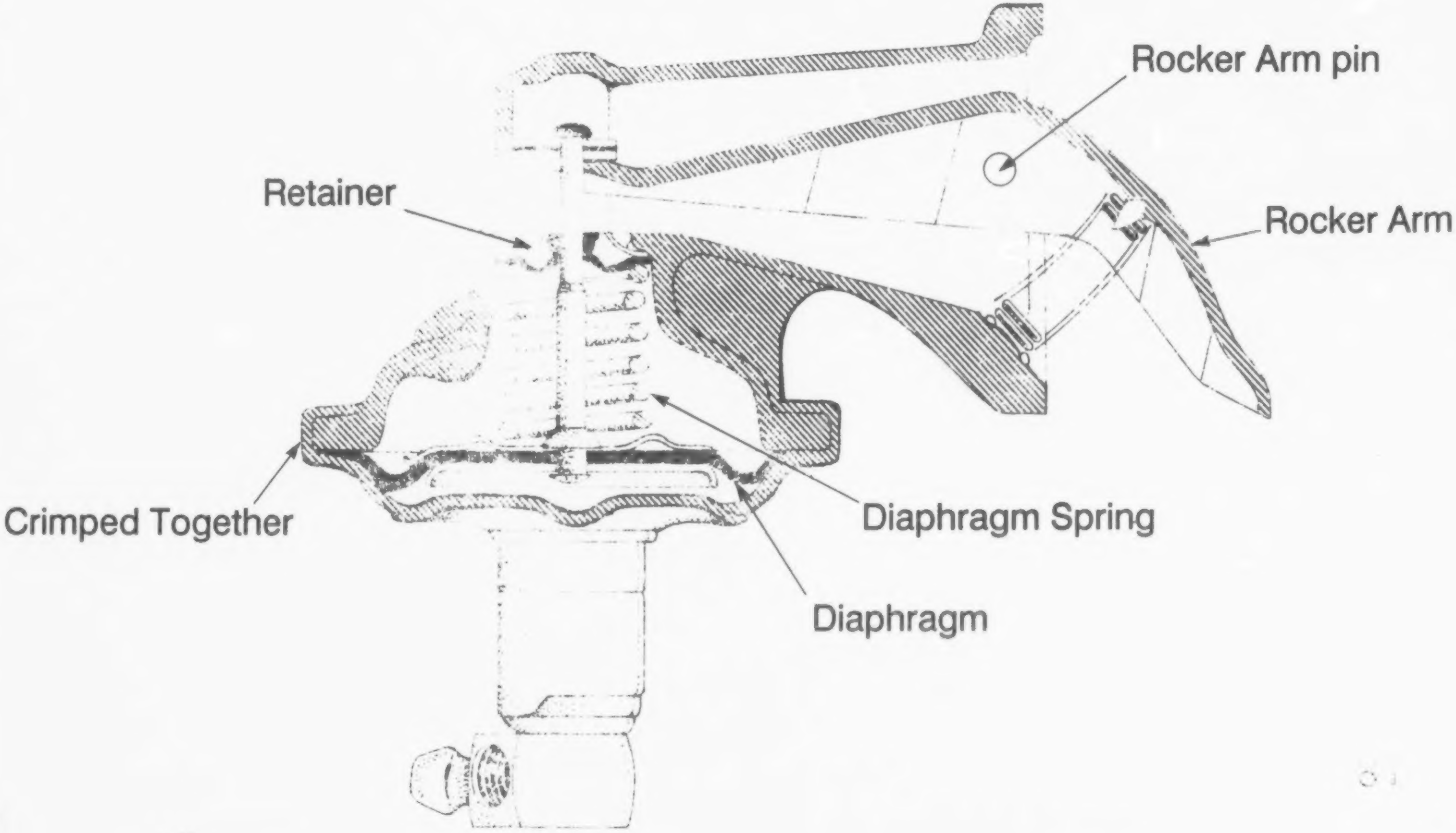
Automobile Fuel System


Fuel Intake Valve
Nozzle
Fuel Pump
Fuel Tank
Air and Fuel Mixture
Throttle
Fuel Line

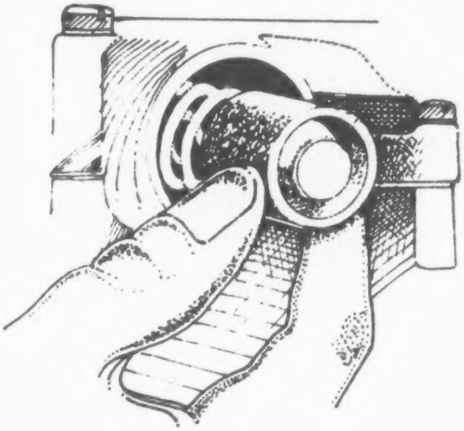
Construction of a Typical Gasoline Tank


Filler Neck
Baffle
Ridges for Strength
Plated Steel
Fuel Transfer Passage
Drain

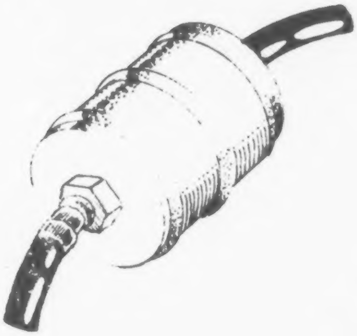
Mechanical Fuel Pump


Rocker Arm pin
Retainer
Rocker Arm
Crimped Together
Diaphragm Spring
Diaphragm

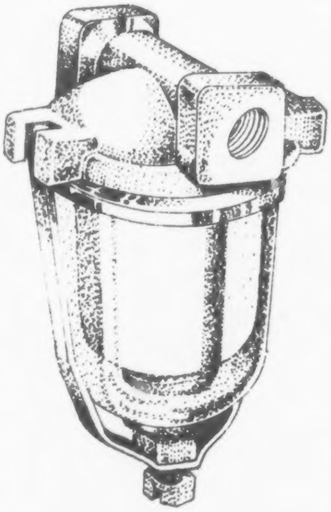
Fuel Filters



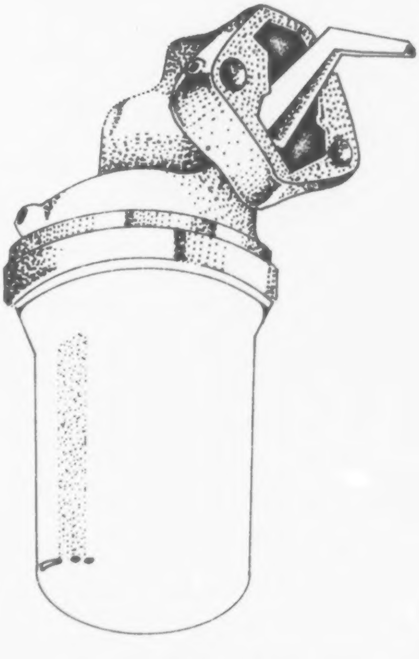
Ceramic



In-Line



Bowl Type

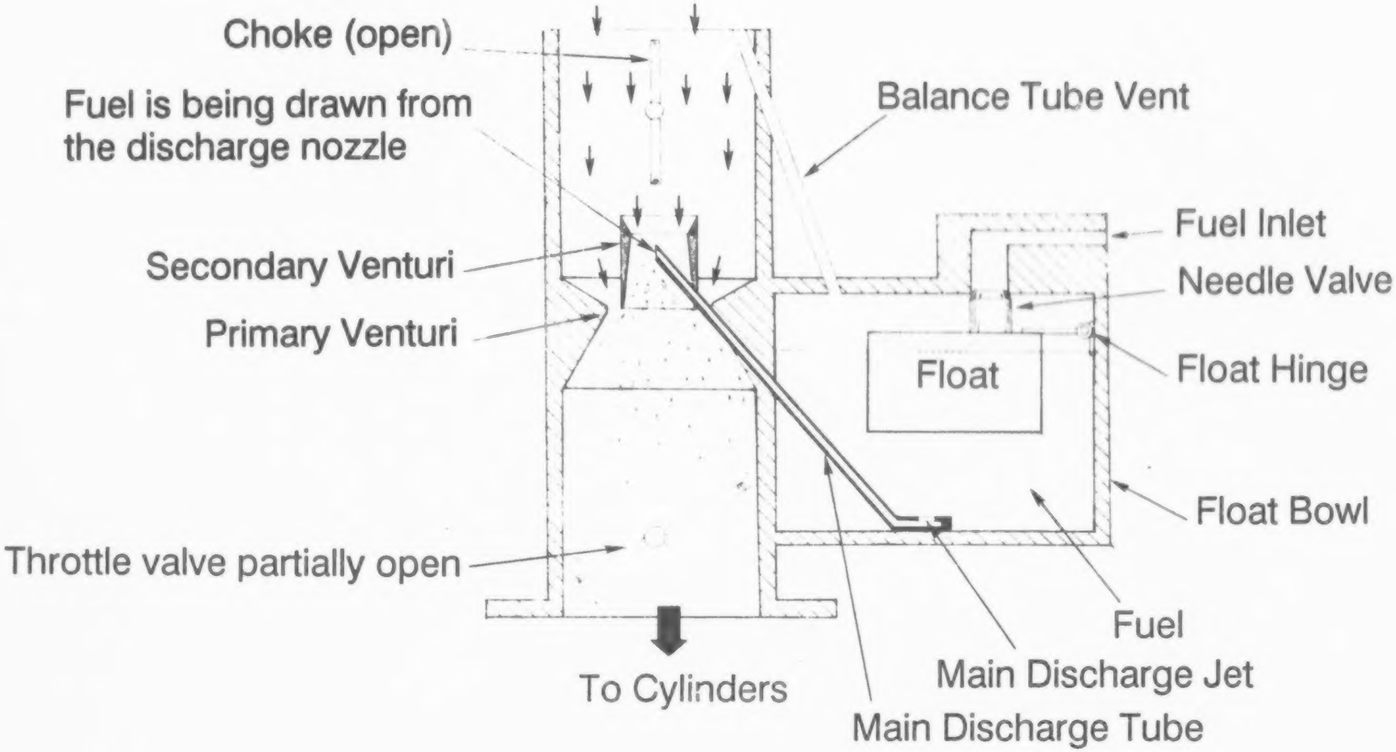


Disposable

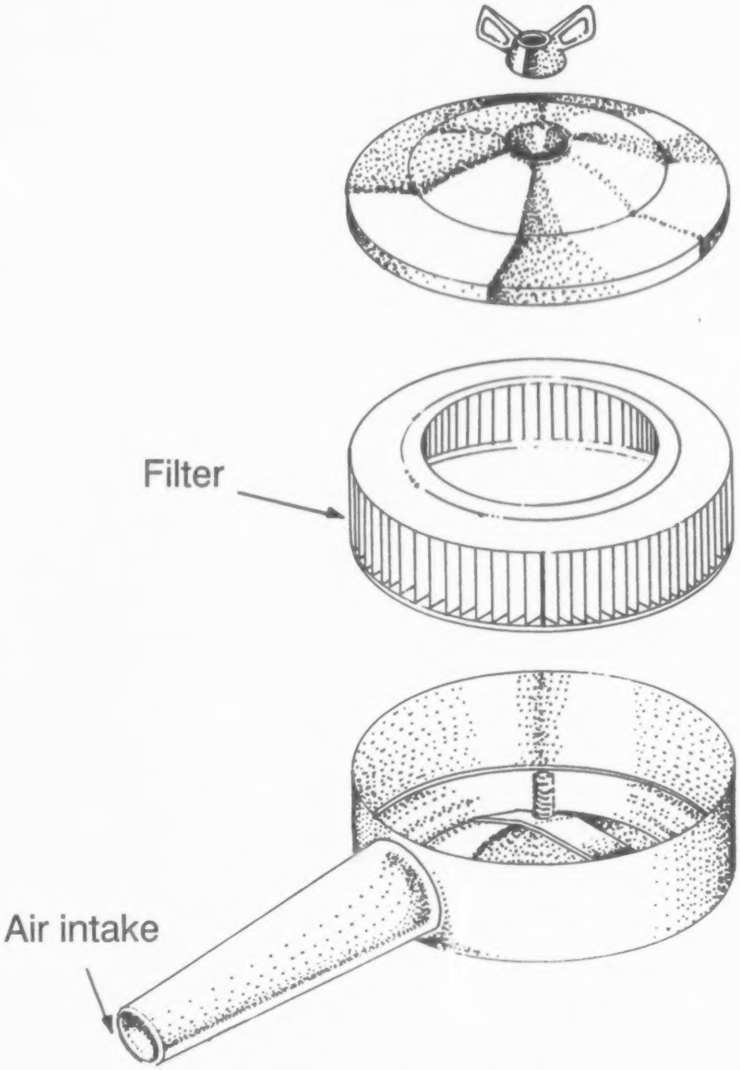
TM-4

BEST COPY AVAILABLE

Basic Carburetor


Choke (open)
Fuel is being drawn from the discharge nozzle
Secondary Venturi
Primary Venturi
Throttle valve partially open
To Cylinders
Balance Tube Vent
Fuel Inlet
Needle Valve
Float Hinge
Float
Float Bowl
Fuel
Main Discharge Jet
Main Discharge Tube

Air Filter


Filter
Air intake

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ **DATE** ____________________

UNIT: Fuel System Operation and Repair

TOPIC: Fuel System

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the automotive fuel system.

2. Match the terms and definitions associated with the fuel system by placing the correct number to the left of each definition:

_____a. Metal plates separating the fuel tank into sections, yet allowing fuel to pass slowly between them

_____b. Device used to measure quantity of fuel in the fuel tank

_____c. A device made of thin layers of cloth bound together with a special compound that makes it airtight and resistant to petroleum products

_____d. To go from a low speed to a high speed

1. Diaphragm
2. Baffles
3. Sending unit
4. Accelerate

3. Describe the construction of the fuel tank by underlining the correct answer for each of the following sentences:

   a. A metal container for the storage of (water, fuel).

   b. Contains (baffles, floats) to keep the fuel from shifting or sloshing.

c. Contains a vent so that fuel may (expand, freeze).

d. Has a (filler opening, drain plug) to allow fuel to enter the tank.

e. Houses a sending unit that gives an accurate description of the (rate of flow, amount) of gas in the tank.

4. Select the proper uses of fuel lines by writing **true** or **false** beside each of the following statements:

_____a. Fuel lines are used to transmit fuel to the engine.

_____b. Fuel lines are constructed of flexible rubber.

_____c. Fuel lines are constructed of steel, approximately 5/16-in. in diameter.

5. Point out the operation of the fuel pump by underlining the correct answer for each of the following:

a. Receives fuel from the fuel tank and (stores it for, sends it to) the carburetor

b. A (diaphragm, siphon) type pump

c. Driven by the (crankshaft, camshaft)

6. Locate the different fuel filters and explain the purpose of these filters by underlining the correct answers:

a. Fuel filters are located in which of the following?

(1) in the tank at the fuel suction pick-up
(2) in the gas-filler spout
(3) in the engine manifold
(4) in the fuel pump inlet
(5) between the pump and carburetor

b. The purpose of fuel filters is to:

(1) remove air bubbles from the fuel
(2) remove dirt and water from the fuel

7. Explain the operation of the carburetor by circling the correct answer for each of the following:

a. A device that mixes fuel with (water, air, carbon dioxide) for entry into the engine

b. Mixes fuel and air at a ratio of 13 parts (fuel, air) to 1 part (fuel, air)

c. Houses three fuel routes:

(1) idle circuit
(2) short circuit
(3) high-speed circuit
(4) acceleration circuit

II-3-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT:	Fuel System Operation and Repair
TOPIC:	Remove Fuel Tank
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to remove the fuel tank correctly.
TOOLS AND EQUIPMENT:	Socket set Hose clamp pliers Common screwdriver Phillips screwdriver
GENERAL INSTRUCTIONS:	The fuel should be drained and the tank removed, with supervision outside of the shop to avoid fires.

PROCEDURES AND/OR TASKS:

Safety Warning: The fuel should be drained and tank removed outside of shop to avoid fires.

1. Check tank for fuel capacity.

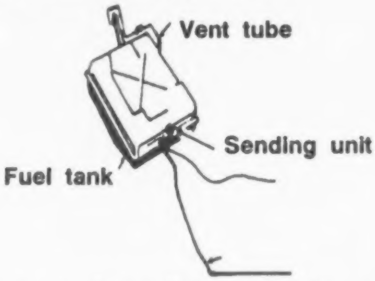
   Note: *Use safety precautions.*

2. Remove gas tank cap.

3. Drain (or siphon) fuel from tank at bottom of drain plug.
   Note: *Make sure container will hold fuel drained.*

4. Disconnect fuel feed line with hose clamp pliers.

5. Disconnect vent line with hose clamp pliers.



6. Disconnect electric wires at tank-sending unit using a common screwdriver.

7. Remove screws around filler neck and remove fairing.

8. Examine the sending unit for problems.

9. Check float to see if it will float.

10. Remove wire from sending unit and touch it to the frame of car.
Note: *Gauge should read full.*

11. Remove and replace sending unit if necessary.

12. Install drain plug in gas tank if removed.

13. Insert tank sending-unit in tank with float in down position.

14. Secure the ring and screws.

15. Connect the vacuum line and secure the hose clamp.

16. Connect the fuel feed line with hose clamp pliers.

17. Connect the electrical wire with a screwdriver or nut driver.

18. Fill the tank with gasoline and check for leaks.

19. Check the gauge in the car to see if it shows the right amount.

20. Have instructor check work

21. Replace tools and equipment.

22. Clean work area.

II-3-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ DATE ____________________

UNIT: Fuel System Operation and Repair

TOPIC: Repair Fuel Tank Indicating System

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to repair fuel tank correctly.

TOOLS AND EQUIPMENT:

- Drain pan
- Combination wrenches
- Common screwdriver
- Phillips screwdriver
- Hose clamp pliers
- Nut driver set

GENERAL INSTRUCTIONS: This job should be done outside the shop and with supervision.

PROCEDURES AND/OR TASKS:

Safety Warning: This job must be performed outside shop. Use safety precautions.

1. Drain tank to amount below the level of tank indicating unit from drain plug at tank bottom or by siphoning.
2. Remove wire, vent, and feed line from tank-sending unit, using common screwdriver and hose clamp pliers.
3. Turn indicating unit counterclockwise and lift away from tank.
4. With tank unit out, reconnect electrical wire and ground unit to auto frame.
5. Turn the auto ignition key to the ON position.

6. Move float arm on sending unit slowly down and up.

7. Have someone look at fuel quantity gauge.

   Note: *Needle on gauge should vary from full to empty as float is being moved. If the needle moves off the scale on the full side, the wire to sending unit is grounded. If the needle moves off the scale on the empty side, the gauge is not working.*

8. Loosen bolts holding tank straps and remove.

9. Lower tank carefully to avoid denting.

   Note: *These are basis procedures for removing lower, rear-mounted gas tanks only. For removing gas tanks from Volkswagen, station wagon, Mustang, and others, refer to specific manufacturers' technical manuals.*

10. Have instructor check work.

11. Replace tools and equipment.

12. Clean work area

II-3-JS-3

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Fuel System Operation and Repair

TOPIC: Check Fuel System for Leaks

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check fuel systems correctly for leaks.

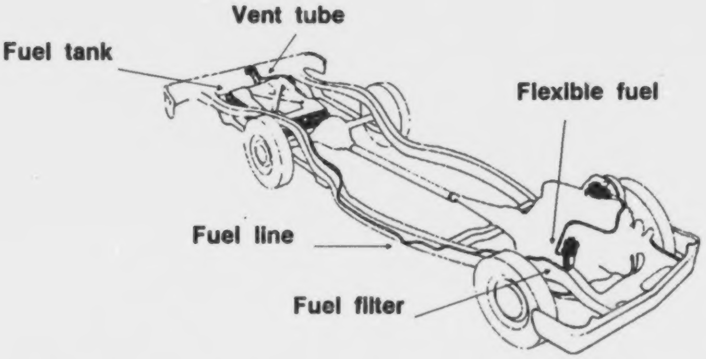
TOOLS AND EQUIPMENT:
Common screwdriver
Hose clamp pliers
Set of open end wrenches

GENERAL INSTRUCTIONS: Be sure tank is full when checking for leaks.

PROCEDURES AND/OR TASKS:

1. Be sure gas tank is full.
   Note: *Use safety precautions.*
2. Check tank for leaks at filler neck, drain plug, vents, and fuel line.
3. Tighten clamps if leaks are found.

4. Check the fuel line along frame toward engine for rubbing and check metal clamps for security.



5. Adjust the line to stop any rubbing and replace any broken clamps.

6. Inspect rubber hose from the metal fuel line to fuel pump inlet.

7. Tighten any leaking clamps and replace the hose if it is cracked.

8. Put car in neutral and secure emergency brake.

9. Start engine.

10. Check the fuel filter and pump for leaks.

11 Tighten any leaking parts.

12. With engine running, check lines from pump to carburetor for leaks.

13 Tighten fittings carefully if there are leaks.

14. When you are satisfied that there are no leaks, turn engine off.

15. Have instructor check work.

16. Replace tools and equipment.

17. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Fuel System Operation and Repair

TOPIC: Remove and Replace Fuel Pump

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace fuel pump correctly.

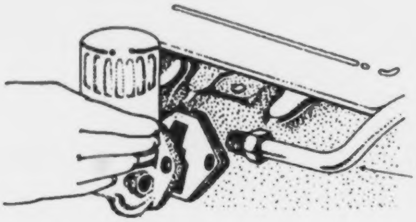
TOOLS AND EQUIPMENT:
Open end wrenches
Socket set
Hose clamp pliers

GENERAL INSTRUCTIONS: Follow procedures below to replace the fuel pump properly.

PROCEDURES AND/OR TASKS:

1. Removal
   Note: *Use safety precautions.*
   a. Using an open end wrench, disconnect outlet line from fuel pump to carburetor.
   b. Disconnect inlet hose from tank with hose clamp pliers.
   Note: *If gasoline drains from tank, put a bolt in line to stop flow.*

   c. Using the socket set, remove mounting bolts from engine block.
   d. Lift fuel pump out from block.



2. Replacement
   a. Install new fuel pump gasket.
   b. Mount fuel pump to block.

   CAUTION: Make sure stroke arm is above camshaft.

   c. Firmly tighten the two mounting bolts.
   d. Remove bolt from tank line and replace to pump using hose clamp pliers.
   e. Install pressure gauge to outlet side of fuel pump and crank engine.

   Note: *The gauge should read from 5 to 7 pounds of pressure.*

   f. Disconnect gauge if reading is satisfactory, and reconnect outlet line to fuel pump.
   g. Put car in neutral and secure emergency brake.
   h. Start engine.

   Note: *If engine continues to run, fuel pump is good.*

   i. If engine fails to continue to run, recheck system.

3. Have instructor check work.

4. Replace tools and equipment.

5. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Fuel System Operation and Repair

TOPIC: Clean or Replace Fuel Filter (Bowl and ceramic insert types)

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(C)

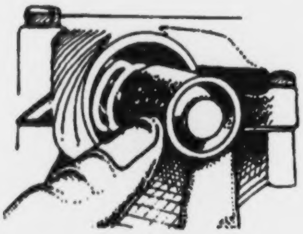
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to clean and replace fuel filter correctly.

TOOLS AND EQUIPMENT:
Hose clamp pliers
Combination wrenches
Air hose
Flare nut wrenches

GENERAL INSTRUCTIONS: This procedure should be done outside the shop or inside with supervision.

PROCEDURES AND/OR TASKS: **CAUTION: Procedure should be done outside shop.**

1. Ceramic filter
   a. Remove the ceramic filter at the carburetor.



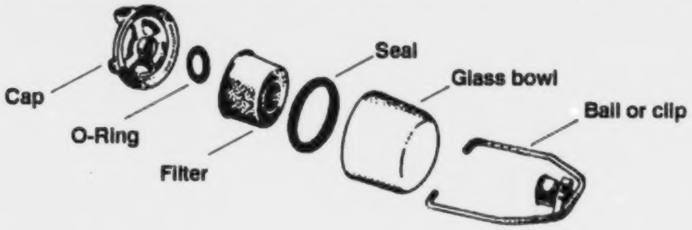
b. Using air hose, apply air on outlet side of filter blowing all trash out the inlet side.

Note: *If filter cannot be cleaned, it should be replaced.*

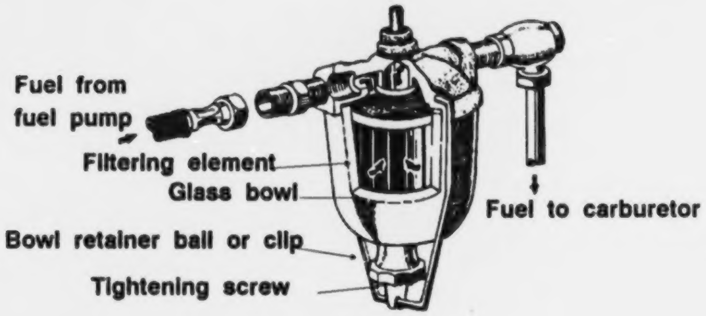
c. Replace filter with the small inner cone away from the carburetor.

2. Bowl-type filter

a. Release hold-down screw of wire bail on fuel filter glass bowl.


Cap
O-Ring
Filter
Seal
Glass bowl
Bail or clip

b. Remove trash from bowl.
c. Check bowl gasket for condition and replace if necessary.
d. Clean screen at top of bowl.
e. Install bowl and tighten hold-down thumb nut on bail.
f. Operate system and check for leaks.


Fuel from
fuel pump
Filtering element
Glass bowl
Bowl retainer bail or clip
Tightening screw
Fuel to carburetor

3. In-line and disposable filters
Note: *These filters should be replaced only.*

4. Have instructor check work.

5. Replace tools and equipment.

6. Clean work area.

II-3-JS-6

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

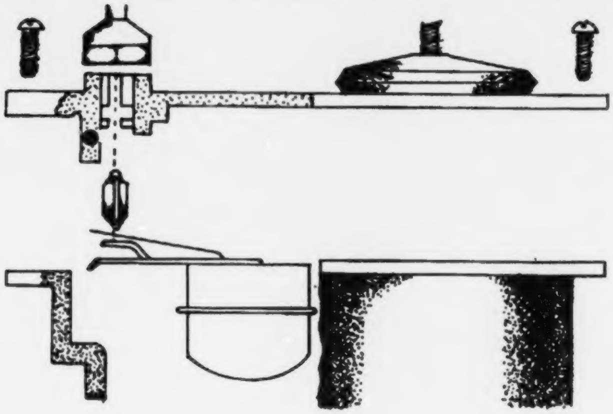
NAME ______________________________ DATE ________________

UNIT:	Fuel System Operation and Repair
TOPIC:	Check and Replace Needle Valve in Carburetor
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to check and replace needle valve in carburetor correctly.
TOOLS AND EQUIPMENT:	Open end wrenches Phillips screwdriver Common screwdriver Combination wrenches
GENERAL INSTRUCTIONS:	Follow procedure to replace the needle valve correctly.

PROCEDURES AND/OR TASKS:

1. Remove air filter by loosening wing nut.
2. Disconnect any controls to top of carburetor, using screwdriver.
3. Remove air filter hold-down bolt with ½-in. x 9/16-in. open end wrench.
4. Disconnect inlet line from fuel pump using crescent and open end wrench.

5. Using a screwdriver, remove all screws from top of carburetor.



6. Lift top off carburetor.
7. Remove float and needle valve.
8. Remove all dirt particles from valve seats and bowl.
9. Check condition of needle valve and replace if necessary.
10. Replace the float, using a gauge to set float height and float drop accurately.
11. Have instructor check work.
12. Replace the carburetor top and tighten the screws with a common screwdriver.
13. Replace air filter hold-down bolt, using a open end wrench.
14. Connect fuel inlet line from carburetor with a crescent and open end wrenches.
15. Replace all connections that were removed from the top of the carburetor.
16. Replace air filter, using wing nut.
17. Crank engine and look at carburetor for leaks.
18. Replace tools and equipment.
19. Clean work area.

II-3-JS-7

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Fuel System Operation and Repair

TOPIC: Remove and/or Replace Air Filter

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B) (ddd)(1)(C)

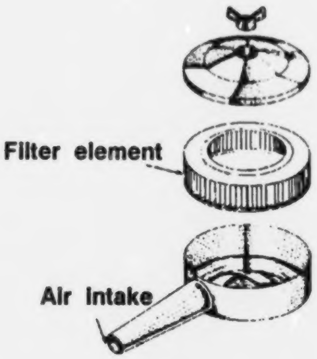
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and/or replace air filter correctly.

TOOLS AND EQUIPMENT:
Pliers
Dry or paper type filter

GENERAL INSTRUCTIONS: Follow procedures to remove or replace air filter correctly.

PROCEDURES AND/OR TASKS:

1. Dry or Paper Type Filter



   - a. Remove wing nut at top of carburetor.
   - b. Lift off filter cover.
   - c. Remove and inspect filter for condition.
   - d. Replace as necessary.
   - e. Replace cover over filter.
   - f. Replace wing nut and tighten.

2. Have instructor check work.

3. Replace tools and equipment.

4. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Electrical System

TOPIC: Electrical Systems

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(D), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to explain the purpose of the electrical system and operation of the electrical system.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to find and repair open and shorted circuits.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with electrical systems include mathematics, application of reading concepts and skills and oral and written communications.*

The Electrical System

The purpose of any electrical system is to furnish a source of power (electrical), to establish paths (circuits) through control devices (switches), and operate units (motors) within a given system.

Terms and Definitions

Atom is a basic unit which, when in combination with other units, makes up molecules.

Bulb is a unit in the electrical system designed to give off light.

Circuit is the path through which electricity flows.

Circuit breaker is a reusable unit located in a wire to prevent an overload in the electrical system circuit before the wire burns up.

Conductor is a wire through which electricity flows.

Current is the flow of electrons under pressure through a wire.

Continuity test checks a wire to see if it will allow the proper current to flow through it by connecting an ohmmeter to each end of the wire.

Filament is the fine wire inside the light bulb.

Fuse is a unit located in a wire to relieve an overload in the electrical system before a wire burns up.

Hydrometer is a device used to check the electrolyte condition of individual battery cells.

Molecules are the smallest particles of a substance or material.

Resistance is a force applied by types of metals in an electrical system that slows down the flow of electricity.

Solder is soft metal that melts easily; used to weld wires together.

Switch is a device for opening or closing the path through which electricity flows.

Wire is a coated strand of metal through which electricity flows.

Factors Determining Electricity Output

Amperage is the rate of current flow of electricity.

Ohm is the measure of resistance to the flow of electricity.

Voltage is the pressure with which electricity is forced through a wire.

Types of Current

AC is alternating current as used in home electric systems; changes directions.

DC is direct current as supplied by batteries; flows in one direction.

Types of Circuits

Parallel circuit is a circuit wired to allow power to all units at the same time.

Series circuit is a type of circuit in which the units within the circuit are located one after another so that the current passes through each unit to get to the next.

Storage Battery

Battery is a storage place for electricity where chemical energy is converted into electrical energy.

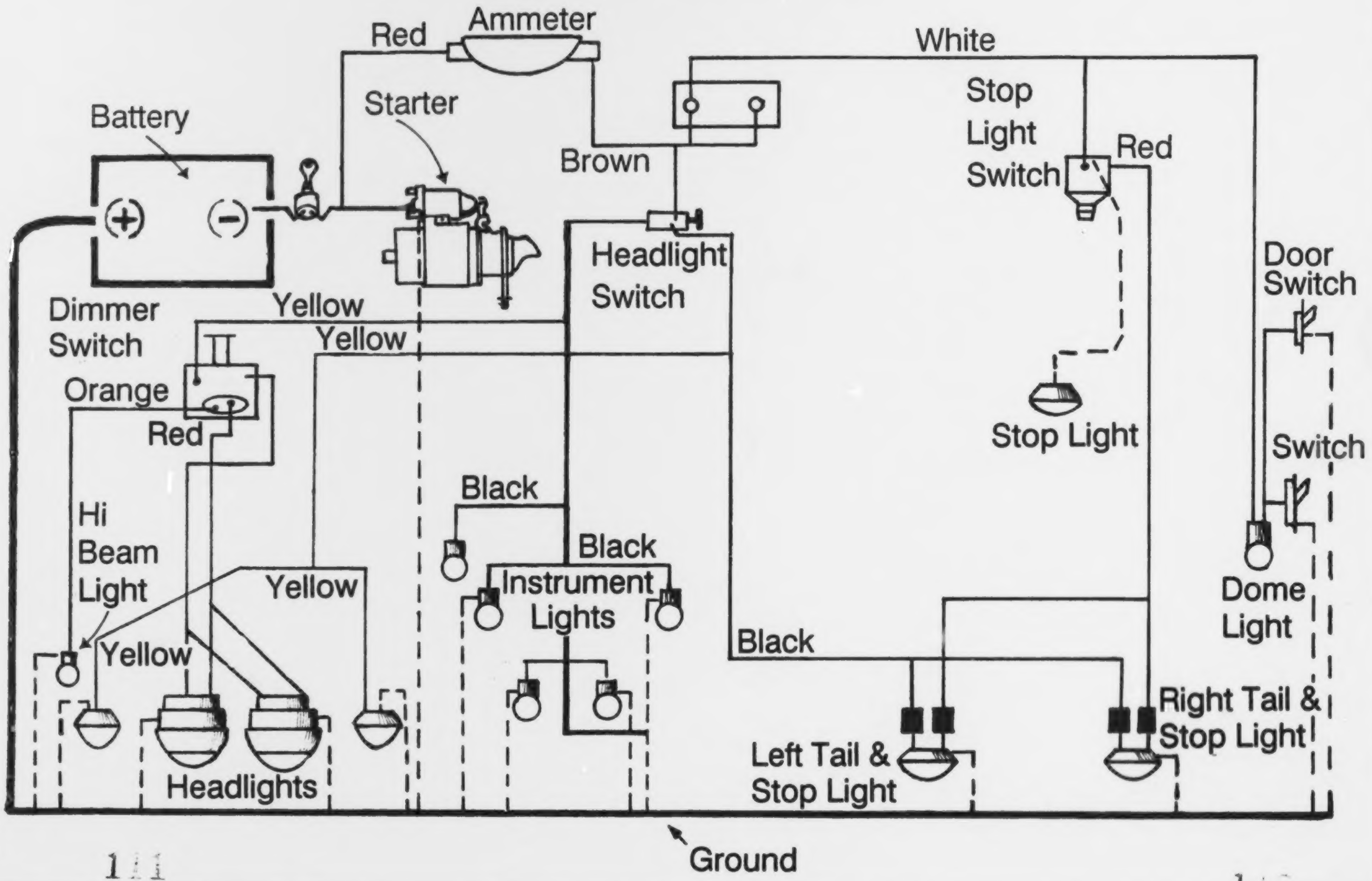
Cells are part of the battery containing 2 volts.

Electrolyte is the liquid used in the battery which is made up of water and sulfuric acid.

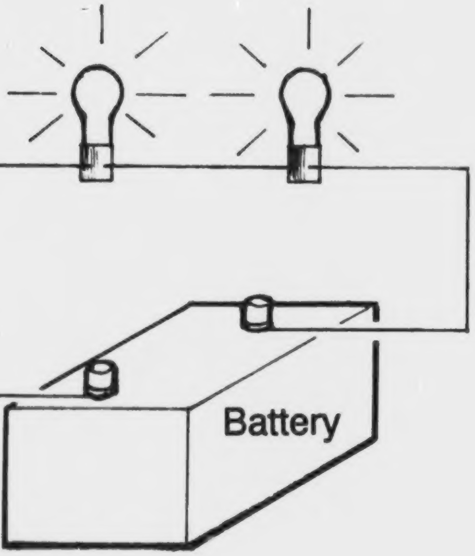
Negative post is the minus side of the battery where electricity leaves the battery through a circuit to all the units.
Note: *It is the smaller post, which will have - (minus) on top and will be painted green.*

Positive post is the plus side of the battery where the electricity returns to the battery.
Note: *It is the larger post, which will have a + (plus) on its top and will be painted red.*

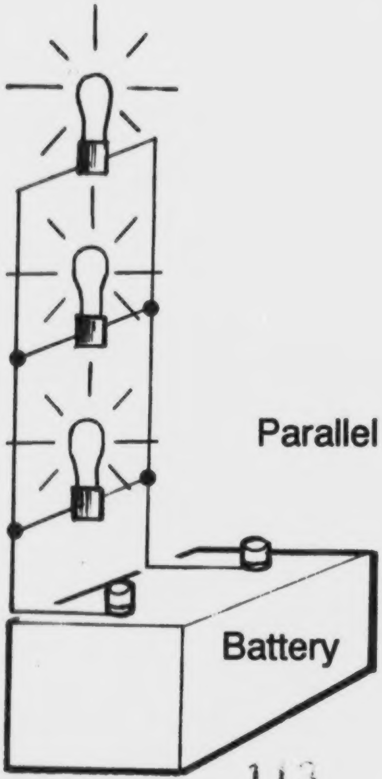
Lighting Circuit


Red
Ammeter
White
Starter
Battery
Brown
Stop
Light
Switch
Red
Headlight
Switch
Door
Switch
Dimmer
Switch
Yellow
Yellow
Orange
Red
Stop Light
Switch
Black
Hi
Beam
Light
Black
Instrument
Lights
Yellow
Dome
Light
Black
Yellow
Right Tail &
Stop Light
Left Tail &
Stop Light
Headlights
Ground

Series and Parallel Circuits

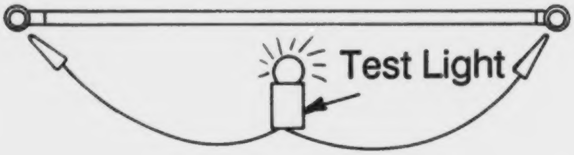


Series Circuit

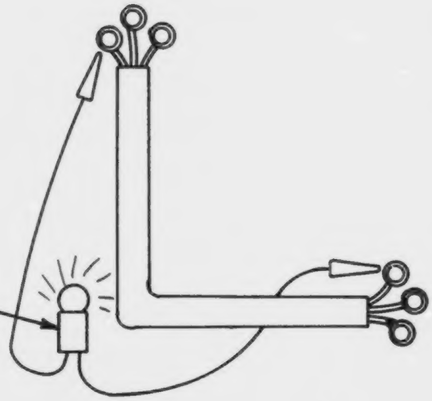


Parallel Circuit

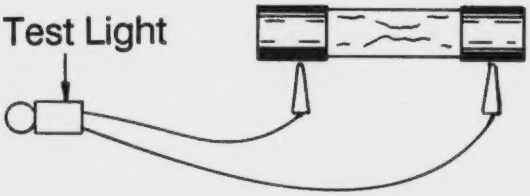
Wiring Tests



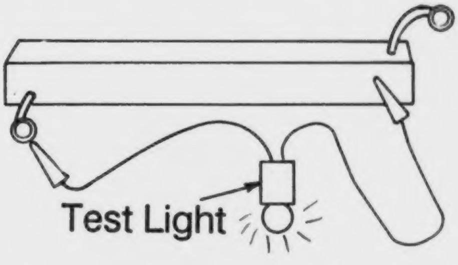
A. Testing a Wire



B. Locating a Circuit

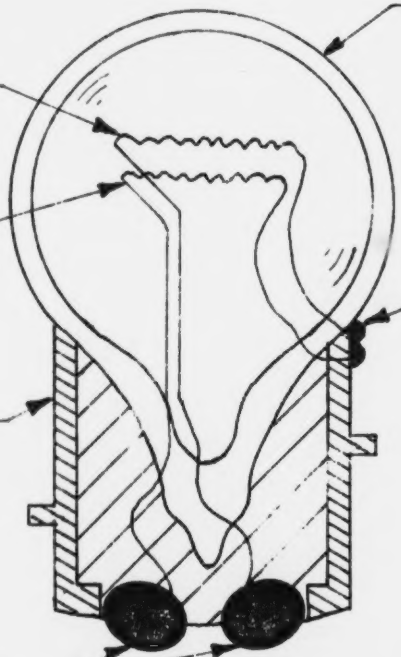


C. Checking a Fuse



D. Checking for Ground

Electric Light Bulb



(1) Glass Bulb

(2) Stop Filament

(3) Park Filament

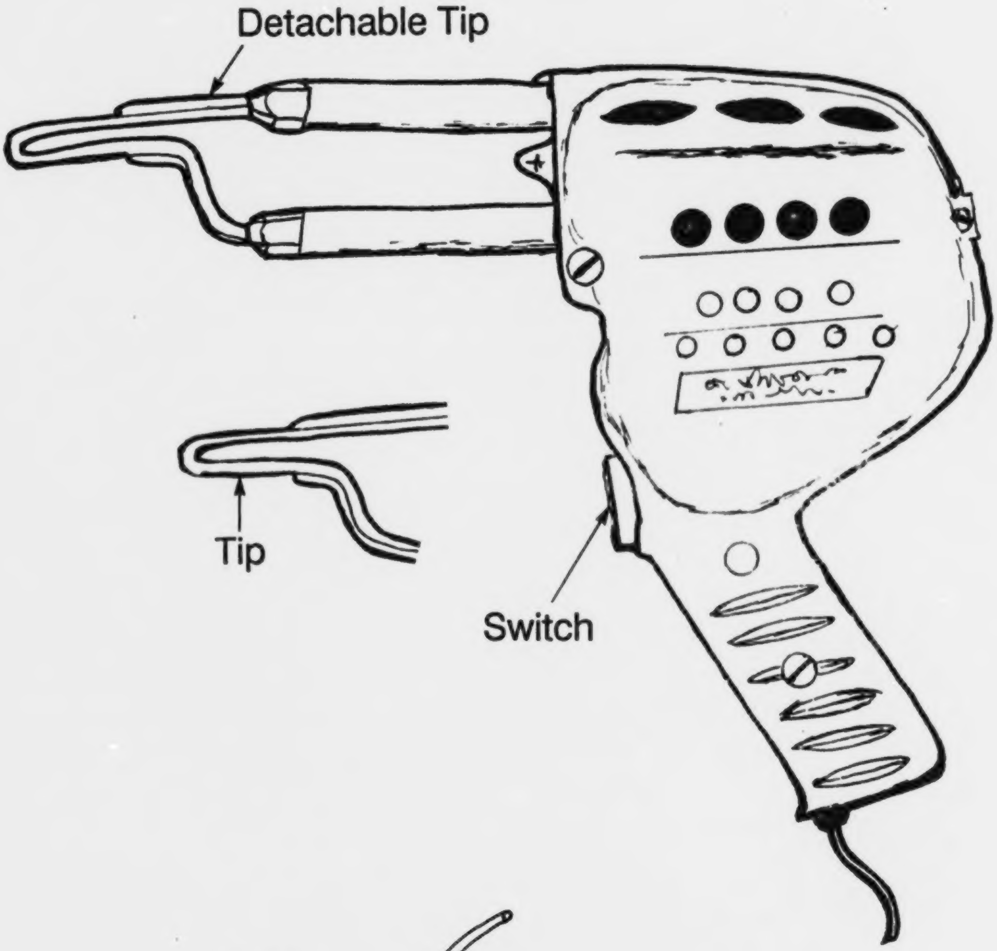
(4) Filament Ground

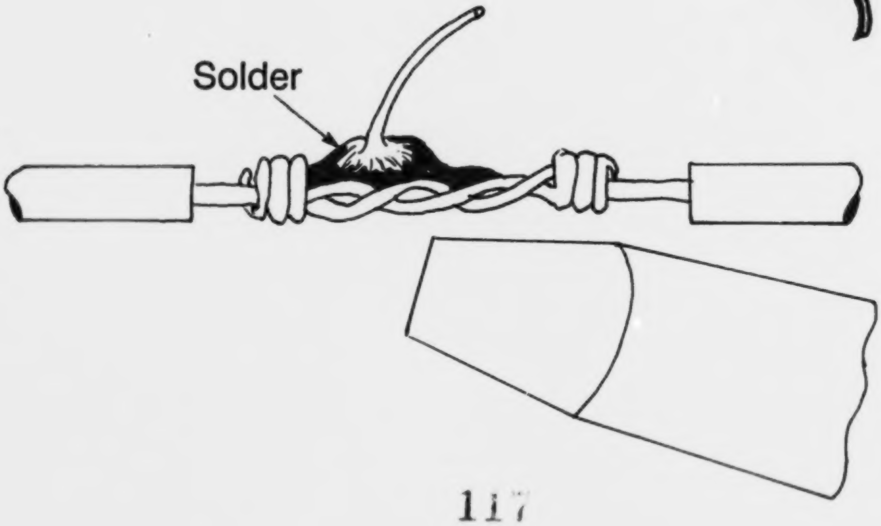
(5) Brass Base

(6) Contact Points

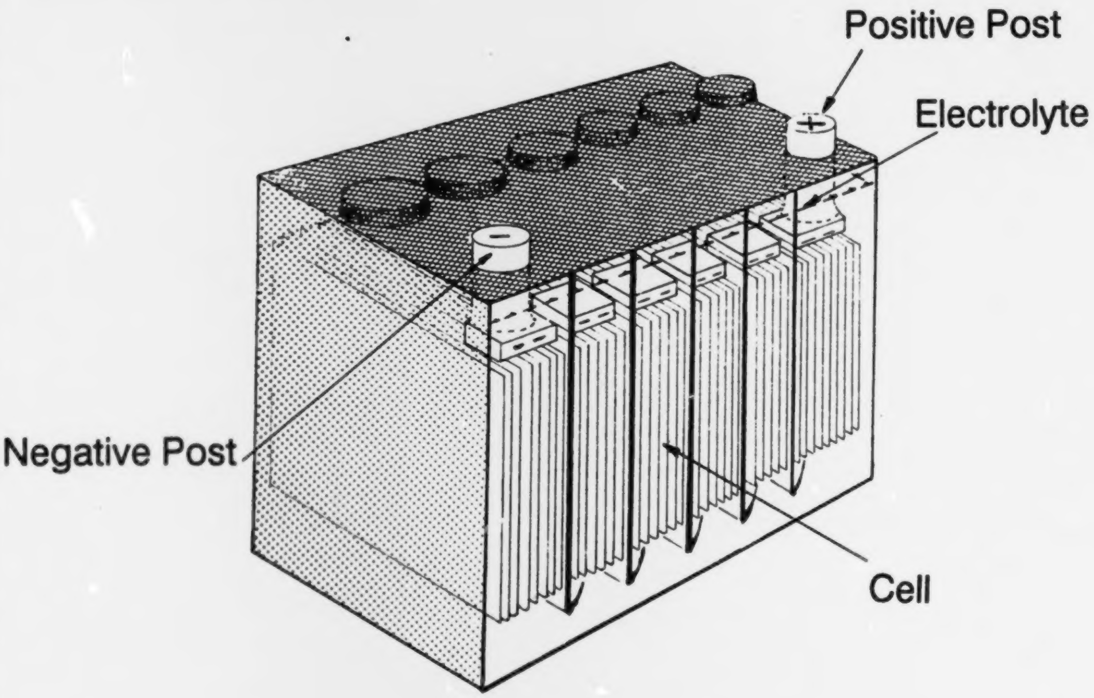
TM-4

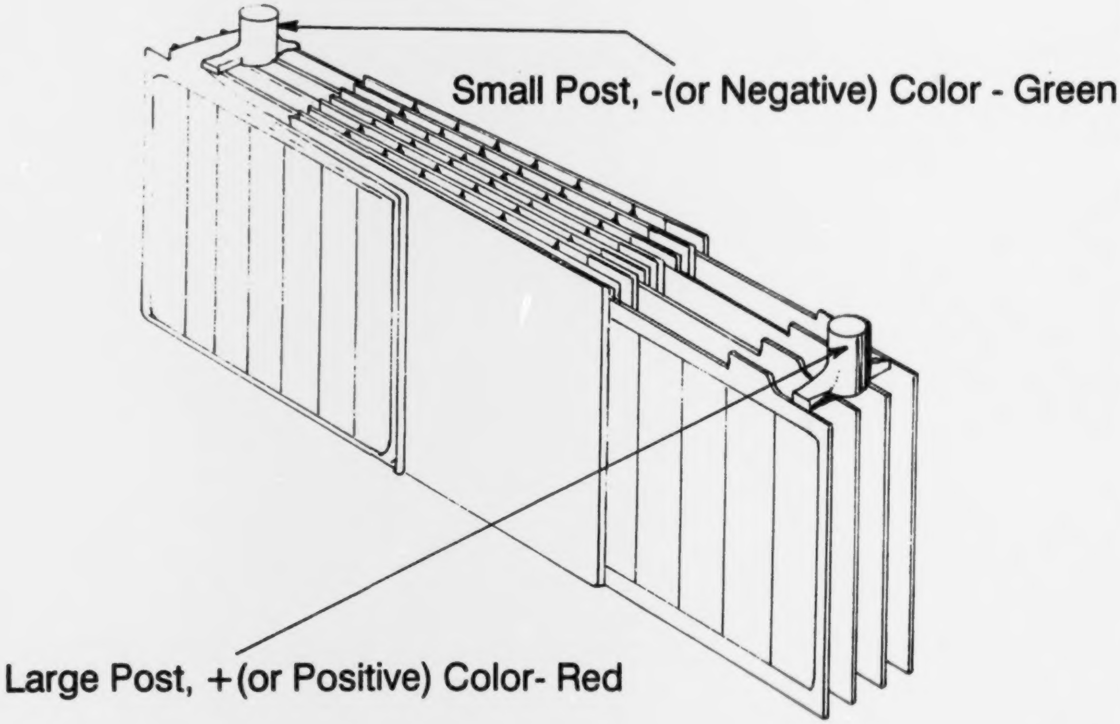
Soldering


Detachable Tip
Tip
Switch

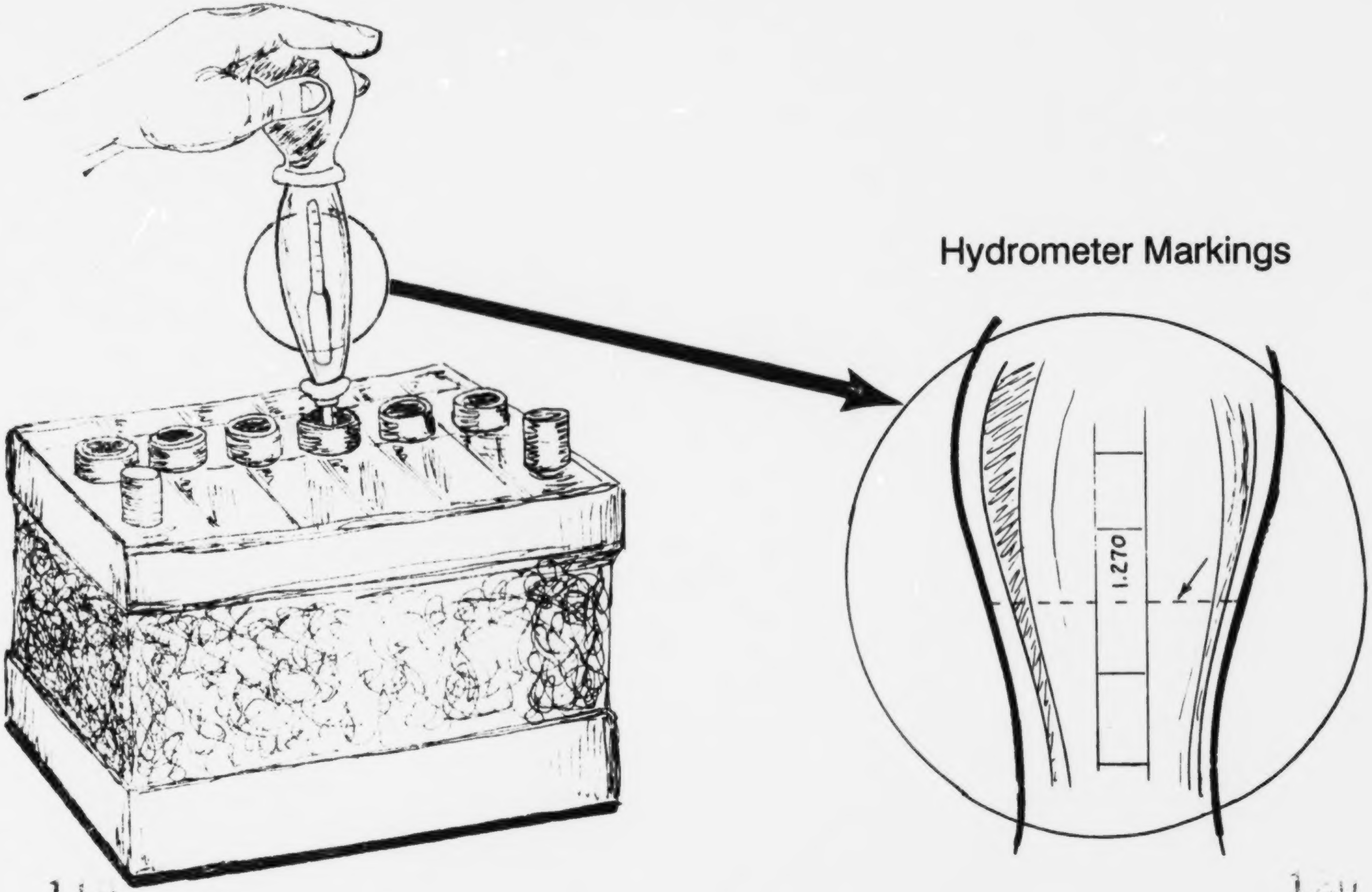


Battery (Wet Cell)


Positive Post
Electrolyte
Negative Post
Cell

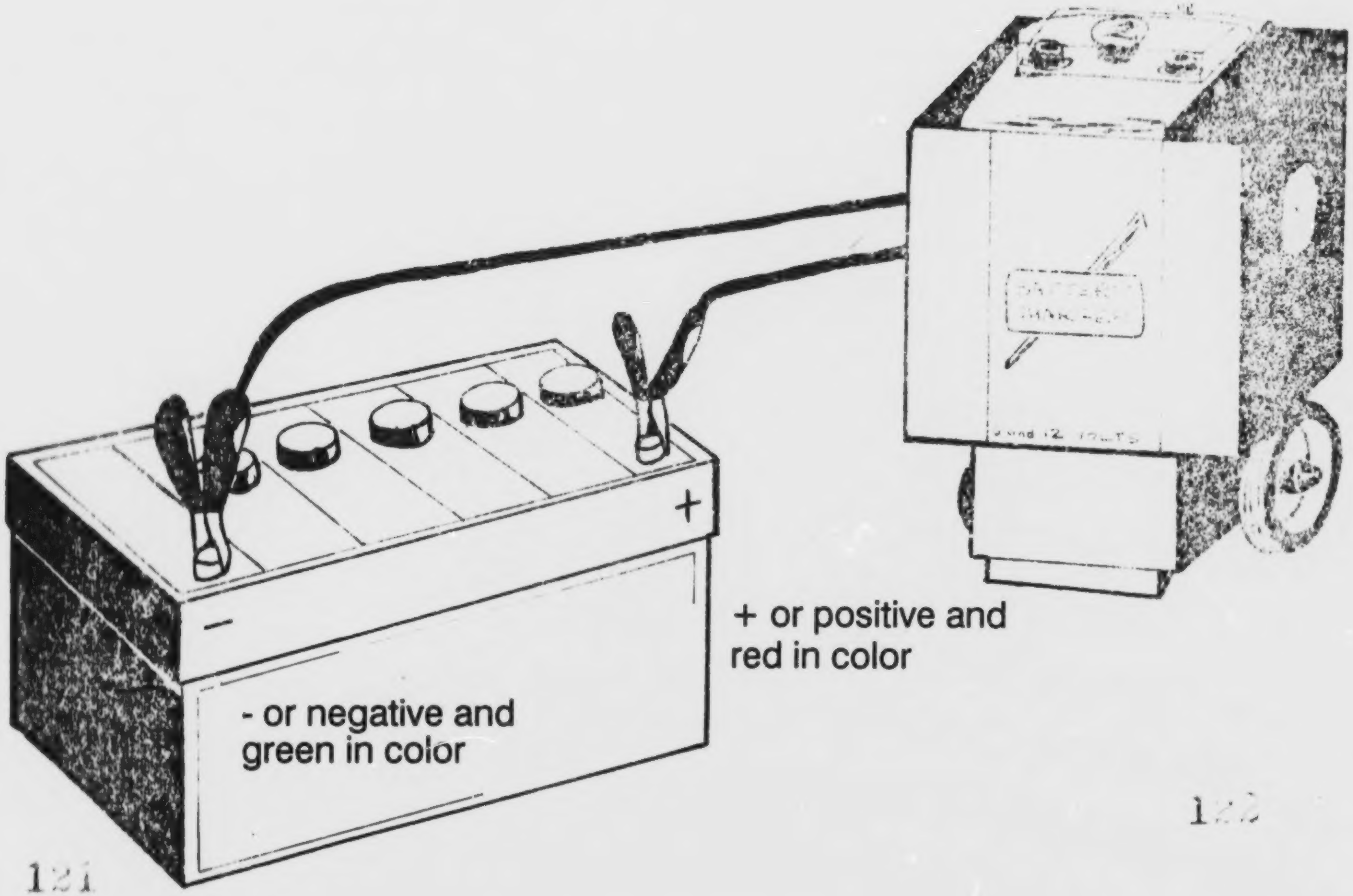

Small Post, -(or Negative) Color - Green
Large Post, +(or Positive) Color- Red

Battery Test


Hydrometer Markings
1.270

TM-7

Battery Charger Connections


+
−
BATTERY CHARGER
6 and 12 VOLTS

+ or positive and red in color

- or negative and green in color

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Electrical System

TOPIC: Electrical Systems

DIRECTIONS: Read and answer the following questions in the space provided.

1. List the four functions for which the electrical system provides power:

   1.

   2.

   3.

   4.

2. Match terms with definitions associated with the electrical system.

   _____a. The flow of electrons under pressure through a wire

   _____b. A coated strand of metal through which electricity flows

   _____c. A device for opening or closing the path through which electricity flows

   _____d. A soft metal that melts easily, which is used to weld wires together

   _____e. A unit in the electrical system designed to give off light

   _____f. The fine wire inside the light bulb

   1. Molecule
   2. Bulb
   3. Solder
   4. Resistance
   5. Switch

_____g. A force applied by types of metals in an electrical system that slows down the flow of electricity

_____h. A basic unit which, when in combination with other units, makes up molecules

_____i. The smallest particle of a substance or material

_____j. A replaceable unit located in a wire that melts to relieve an overload in the electrical system

_____k. A reusable unit located in a wire that melts to relieve an overload in the electrical system before the wire burns up

_____l. The path through which electricity flows

_____m. A wire through which electricity flows

_____n. Checking a wire to see if it will allow current to flow through it by connecting an ohmmeter to each end of the wire

6. Atom
7. Wire
8. Filament
9. Current
10. Circuit
11. Conductor
12. Circuit breaker
13. Fuse
14. Continuity test

3. Select the terms describing each factor that determines electricity output by placing the correct letter to the left of each letter.

_____a. The rate of flow of electricity

_____b. The measure of resistance to the flow of electricity

_____c. The pressure with which electricity is forced through a wire

1. Ohm
2. Voltage
3. Amperage

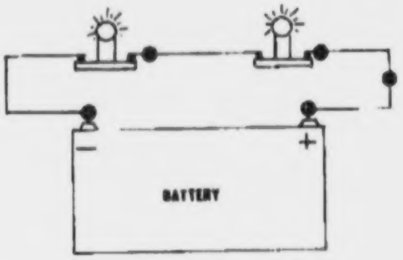
4. Determine the type of currents (AC or DC) produced in each of the different sources.

_____a. Current supplied by batteries

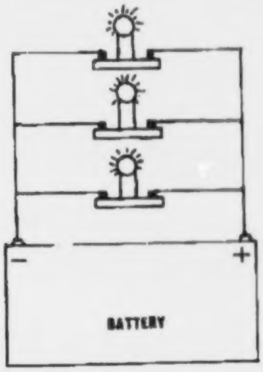
_____b. Current used in home electrical systems

5. Label each circuit as series or parallel circuits.

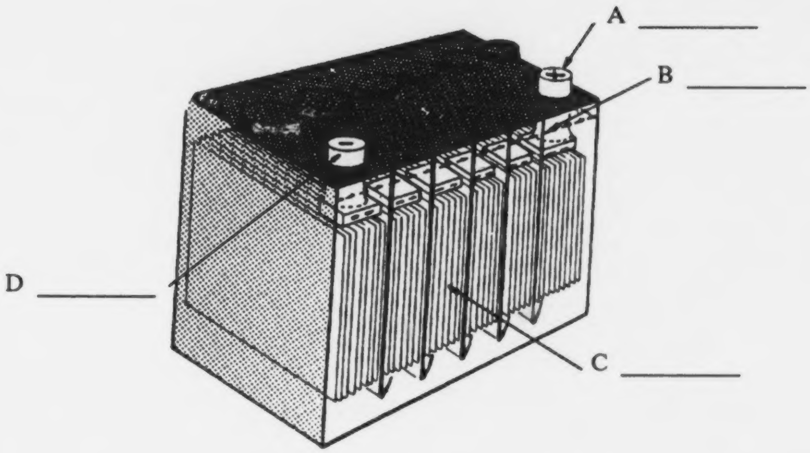
______________________ a.



______________________ .b.



6. Point out the parts of a battery by labeling each of numbered parts with one of the following:
positive post
negative post
electrolyte
cells



II-4-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Electrical System

TOPIC: Test Light Bulbs

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(D), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to test light bulbs correctly.

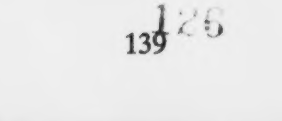
TOOLS AND EQUIPMENT:
Ohmmeter (set on ohms)
Good light bulb (two terminal)
Burned-out light bulb (two terminal)

GENERAL INSTRUCTIONS: Use ohmmeter leads to test bulbs.

PROCEDURES AND/OR TASKS:

1. Connect ohmmeter to brass base of burned-out light bulb and to one base-connector terminal.
   Note: *No reading indicates that filament is burned out.*

2. Change lead to other base terminal connector.
   Note: *No reading indicates other filament is burned out.*



3. Connect ohmmeter to brass base of good light bulb and one to base-connector terminal.
   Note: *Any reading indicates that filament is good.*
4. Change lead to other base terminal connector.
   Note: *Any reading indicates other filament is good.*
5. Have instructor check work.
6. Replace tools and equipment.
7. Clean work area.

II-4-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Electrical System

TOPIC: Make Splices in Wire (Conductor)

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(7), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to splice wires correctly.

TOOLS AND EQUIPMENT:
One piece of #18 gauge coated wire, 4 ft long
Wire stripper
Diagonal pliers

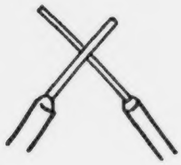
GENERAL INSTRUCTIONS: Using tools and equipment, follow procedures to learn how to splice wires.

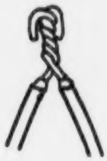
PROCEDURES AND/OR TASKS:

1. Use diagonal pliers and cut wire into four equal-length pieces.
   Note: *Use safety precautions.*

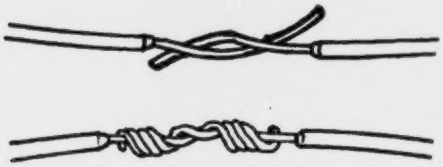
2. Strip approximately 1-in. of coating off the ends of all four pieces of wire.

3. All frayed ends should be twisted individually until smooth.



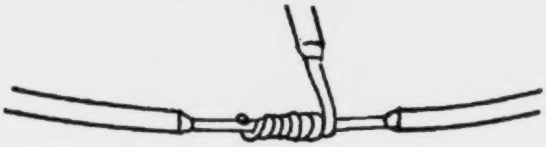


4. Using one piece of wire, complete a "pigtail" splice.



5. Using one piece of wire, complete a "western union" splice.

6. Using two pieces of wire, complete a "tap" splice.



7. Have instructor check work.

8. Replace tools and equipment.

9. Clean work area.

II-4-JS-3

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Electrical System

TOPIC: Solder Wire

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to solder wire connections correctly.

TOOLS AND EQUIPMENT:

Diagonal pliers
One piece of #18 gauge wire, 12-in. long
Wire strippers
Soldering gun
Solder (rosin core)
Electrical source (110 volts)

GENERAL INSTRUCTIONS: Use following procedures to learn how to solder wire connections.

PROCEDURES AND/OR TASKS:

1. Cut 12-in. piece of #18-gauge wire from roll using diagonal pliers.
   Note: *Use safety precautions.*

2. Strip approximately 1-in. of coating off each end of wire.

3. Twist ends of wire counterclockwise until even.

4. Make a "western union splice".
   Note: *Splice should be no more than ½-in. long when completed.*

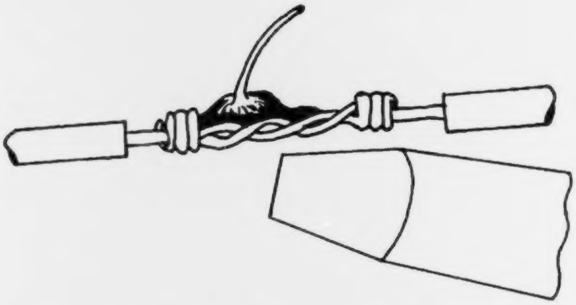
5. Plug in soldering iron.

6. "Tin" tip of iron when hot.
   CAUTION: Care should be used when iron is hot to avoid burns to skin.

7. Place soldering iron under bottom of splice.

8. Add solder (rosin core) to top of wire.
   Note: *When wire becomes hot enough, solder will flow down through splice.*

9. Remove iron and let splice cool.



Note: *Re-apply heat if too much solder remains on splice.*

10. Have instructor check work.

11 Replace tools and equipment.

12. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT:	Electrical System
TOPIC:	Perform Wiring Test
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson the student(s) will be able to perform wiring test correctly.

TOOLS AND EQUIPMENT:

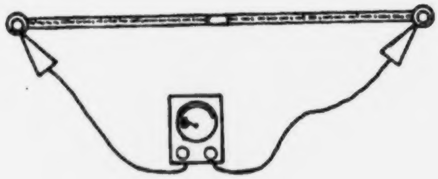
Ohmmeter
Wire mockups

1. Open wire (wire broken under coating)
2. Shorted wire (grounded in metal tube)
3. Identify wire (3 wires wrapped)
4. Two fuses (1 good, 1 blown)

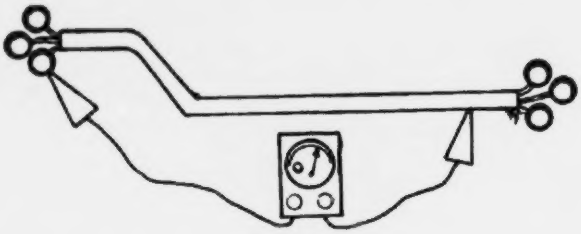
GENERAL INSTRUCTIONS: Use ohmmeter and procedure below to check out wire mockups.

PROCEDURES AND/OR TASKS:

1. Connect ohmmeter to both ends of an **open** wire.
2. Set meter on highest ohm reading on selector.
   Note: *No reading on meter indicates open wire. Any reading on meter indicates good wire.*

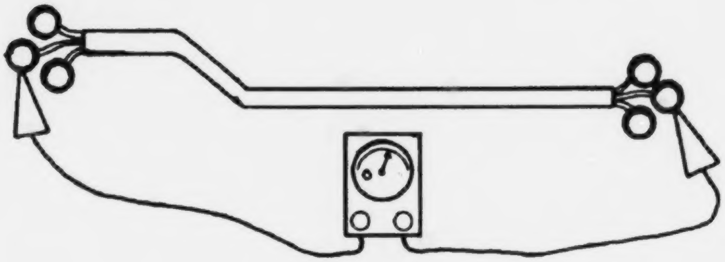


3. Connect ohmmeter to **shorted wire** and side of tube or block through which it passes.
   Note: *No reading indicates wire is not shorted. Any reading indicates short to ground.*

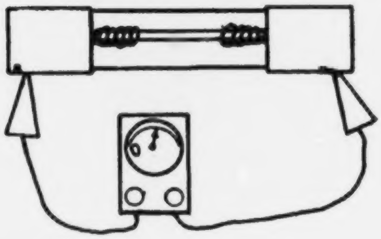


4. Connect ohmmeter to each end of the wire through the tube or block.

5. Read meter individually as ends of one wire are touched.
   Note: *Any reading indicates that wire is continuous.*



6. Touch ohmmeter leads to end of fuse.
   Note: *No reading indicates fuse is blown or open. Any reading indicates fuse is good.*



7. Have instructor check work.

8. Replace tools and equipment.

9. Clean work area.

II-4-JS-5

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Electrical System

TOPIC: Identify Battery Types and Voltages

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to identify batteries and voltages correctly.

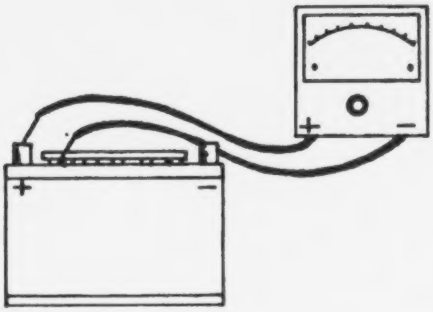
TOOLS AND EQUIPMENT:
One 12-volt battery (wet cell)
One 6-volt battery (wet cell)
Six 1½-volt batteries (dry cell)
Voltmeter

GENERAL INSTRUCTIONS: Use voltmeter and procedures to check and identify methods.

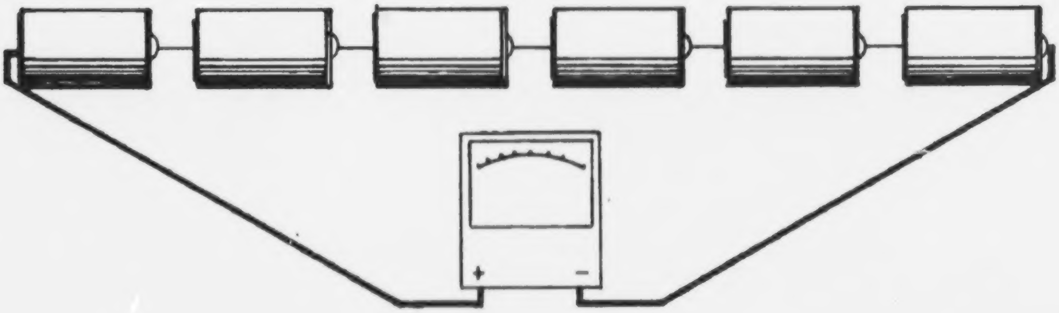
PROCEDURES AND/OR TASKS:

1. Identify on both 6- and 12-volt batteries:
   a. Cell
   b. Cap
   c. Positive post
   d. Case
   e. Negative post

2. Connect a voltmeter to one cell of a battery.



3. Check the voltage of one cell on each battery.
4. Check the voltage of the cells on both batteries.
5. Connect six dry-cell batteries in series and check the voltage.



6. Have instructor check work.
7. Replace tools and equipment.
8. Clean work area.

135

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Electrical System

TOPIC: Remove, Clean, and Replace Battery

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove, clean and replace a battery.

TOOLS AND EQUIPMENT:

Open end wrench set
Soda and water solution
Terminal cleaner
Grease
Safety glasses or face shield
Battery strap

GENERAL INSTRUCTIONS: Follow procedures to remove, clean and replace a battery properly.

PROCEDURES AND/OR TASKS:

1. Raise hood as applicable.
   Note: *Use safety precautions*
2. Remove terminals with $1/2$-in. x $9/16$-in. wrench as required.
3. Remove battery; hold down straps with wrench.
4. Secure battery straps to terminals, if applicable.
   Note: *Put large hole in strap to **Plus** post and small hole in strap to **Negative** post.*

5. Lift battery out of car.
   WARNING: The battery is heavy and filled with corrosive acid. Wear gloves, a face shield and other protective clothing as needed.

6. Place battery on work table.
   Note: *Never place battery on concrete floor as it will discharge battery.*

7. Check and fill cells with distilled water to base of cell filler neck.

8. Clean posts with terminal cleaner.
   WARNING: Do not let this solution enter the cells! It will neutralize the acid and ruin the battery.

9. Clean outside battery case with soda and water solution.

10. Apply a light coat of bearing grease to battery posts.

11. Reinstall battery strap to battery.

12. Replace battery in car.

13. Remove lifting strap.

14. Install hold-down strap on battery.

15. Replace cables to terminals.
    Note: *Place* ***Positive*** *lead first to large post, and tighten; then attach* ***Negative*** *lead to small post and tighten.*

16. Have instructor check work.

17. Close hood.

18. Replace tools and equipment.

19. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Electrical System

TOPIC: Check Battery with Hydrometer

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

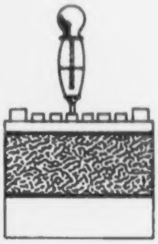
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to use a hydrometer to check batteries properly.

TOOLS AND EQUIPMENT:
Hydrometer
Battery (wet cell)
Safety glasses or face shield

GENERAL INSTRUCTIONS: Follow procedures and check a battery using the hydrometer properly.

PROCEDURES AND/OR TASKS:

1. Raise hood
   Note: *Use safety precautions.*
2. Remove battery caps
3. Pull up sufficient amount of electrolyte into hydrometer to float bulb in liquid.
   Note: *Hold hydrometer vertical.*



4. Read scale for cell condition.
   Note: *General readings:*

Fully charged	1.300 reading
Good charge	1.275 reading
Medium changer	1.215 reading
Low charge	1.175 reading
No charge	1.120 reading

(Correction of readings according to temperature should be made.)

5. Replace caps.
6. Have instructor check work.
7. Close hood.
8. Replace tools and equipment.
9. Clean work area.

Note: *If battery requires charging, do so in accordance with Job Sheet #8.*

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT:	Electrical System
TOPIC:	Connect, Operate and Disconnect a Battery Charger
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to connect, operate, and disconnect a battery charger properly.
TOOLS AND EQUIPMENT:	Socket set Battery charger Safety glasses or face shield
GENERAL INSTRUCTIONS:	Follow procedures to use a battery charger properly.

PROCEDURES AND/OR TASKS:

1. Raise hood.
   Note: *Use safety precautions.*

2. Remove battery caps.

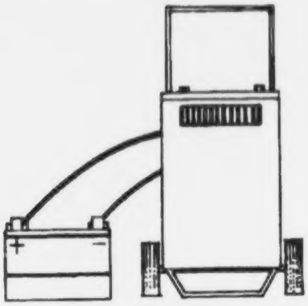
3. Use hydrometer and check condition of battery.

4. Remove negative battery cable.

5. Determine type of battery.
   Example: *6-volt or 12-volt*

6. Check electrolyte level in battery. Add distilled water if necessary.

7. Connect charger to battery.
Note: *Place red charger lead to positive post, black lead to negative post.*



8. Select 6 or 12 volts on charger selector.
9. Plug battery charger into 110-volt outlet.
10. Turn battery charger ON.
11. Using amperage selector on charger select **low**, **medium**, or **high** charge as required.
12. Check with hydrometer for enough charge.
13. When battery is charged, turn charger OFF.
14. Disconnect battery charger cables, negative lead first.
15. Replace battery cables and tighten.
16. Replace battery filler caps (if removed).
17. Roll up all leads to battery charger.
18. Have instructor check work.
19. Close hood.
20. Replace tools and equipment.
21. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE REPAIR

UNIT: Ignition System

TOPIC: Ignition System Terminology

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(C)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to inspect, test, and service the ignition system.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will explain the purpose of the ignition system, test and replace ignition parts.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with the ignition system include mathematics, oral and written communications, reading concepts, and science.*

Ignition Terminology

The ignition system supplies and distributes high-voltage sparks to ignite the fuel-air mixture within the combustion chamber. Each spark is timed to appear at the spark plug gap as the piston approaches top dead center on the compression stroke when the engine is idling.

Terms for Ignition System

Battery is a storage place for electricity where chemical energy is converted into electrical energy

BDC is bottom dead center, the position of the piston when it reaches its lower limit of travel in the cylinder.

Circuit is the path through which electricity flows.

DC current is that supplied by batteries, flows in one direction only.

Firing order is the order in which the cylinders must be fired.

Flashover is an arcing of electricity in the ignition system at a place where the insulation has become faulty.

Fuse is a unit located in a wire or circuit to prevent an overload in the electrical system before the wire burns up.

Ground is the connection of an electrical unit to the engine or frame to return current to its source.

High tension is a term used for high voltage.

Ignition is the process of setting fire to fuel in the combustion chamber by means of a spark.

Induction is the imparting of electricity into one object not connected to another by the influence of magnetic fields.

Magnet is a body of metal that has the ability to attract.

Ohm is the measure of resistance to the flow of electricity.

Pre-igniting is when the fuel-air mixture ignites or burns before it should.

Relay is a magnetically operated switch used to make and break the flow of current in a circuit.

Resistor is a device placed in a circuit to lower voltage.

Short circuit is a hot wire in the electrical system that has become grounded.

TDC is top dead center, the position of the piston when it reaches the highest limit of travel in the cylinder.

Components of the Ignition System

The typical ignition system consists of the bottom starter relay, ignition switch, ballast resister, ignition coil, distributor, spark plug.

The **battery** is a storage place for electricity where chemical energy is converted into electrical energy.

Ballast resistor is a resistor made of a wire which will increase or decrease voltage as the heat of the wire changes.

Coil is a unit used to step up battery voltage to a point necessary to fire a spark plug.

Distributor is a unit designed to make and break the main ignition circuit and distribute the resulting high voltage to the proper cylinder at the right time.

Ignition switch is a device used for opening and closing all electrical circuits on an automobile.

Spark plug is a device with two electrodes which provides an air gap for a spark to jump across and ignite the fuel-air mixture in the combustion chamber.

Starter relay is a switch in the cranking device of an engine.

Components of the Distributor

Cam is a moving part—or irregular or lobed form—that moves or alters the motion of another part.

Condenser is a device between the points and coil that temporarily stores a surge of current that can be discharged as the points close.

The **distributor cap** is an insulated cap in which voltage travels from a central terminal to a circular series of terminals through the rotor.

Rotor is a unit placed on one end of the distributor shaft that takes the voltage from the coil and delivers it to each one of the cap terminals.

Vacuum advance is a unit that moves the ignition timing ahead and back by means of the vacuum produced by the engine.

Condition of Spark Plugs

Aluminum throw-off occurs when plugs are fouled with particles of molten aluminum, caused by the piston breaking up due to rapid combustion, pre-ignition, or over-advanced ignition timing.

Fuel fouling occurs when plug is deposited with black, dry carbon caused either by the plugs being too cold, a high level of fuel in the carburetor, excessive choking, or a clogged air cleaner.

Gap bridging occurs when a plug with carbon-lead deposits connects the two electrodes.

High-speed glazing ocurs when a plug developes a hard, shiny, yellowish-tan deposit caused by a sudden increase in plug temperature during hard acceleration or loading.

Oil fouling occurs when plugs are covered with wet, black deposits caused by an excessive amount of oil reaching the combustion chamber.

Shell bridging oocurs when a plug has a large piece of piston or combustion chamber deposit sticking between the hot insulator and plug shell.

Splashed fouling occurs when new plugs are coated with splashes of carbon deposits because the plugs were installed in an engine that had heavy deposits of carbon in the combustion chamber.

Testing Equipment for the Ignition System

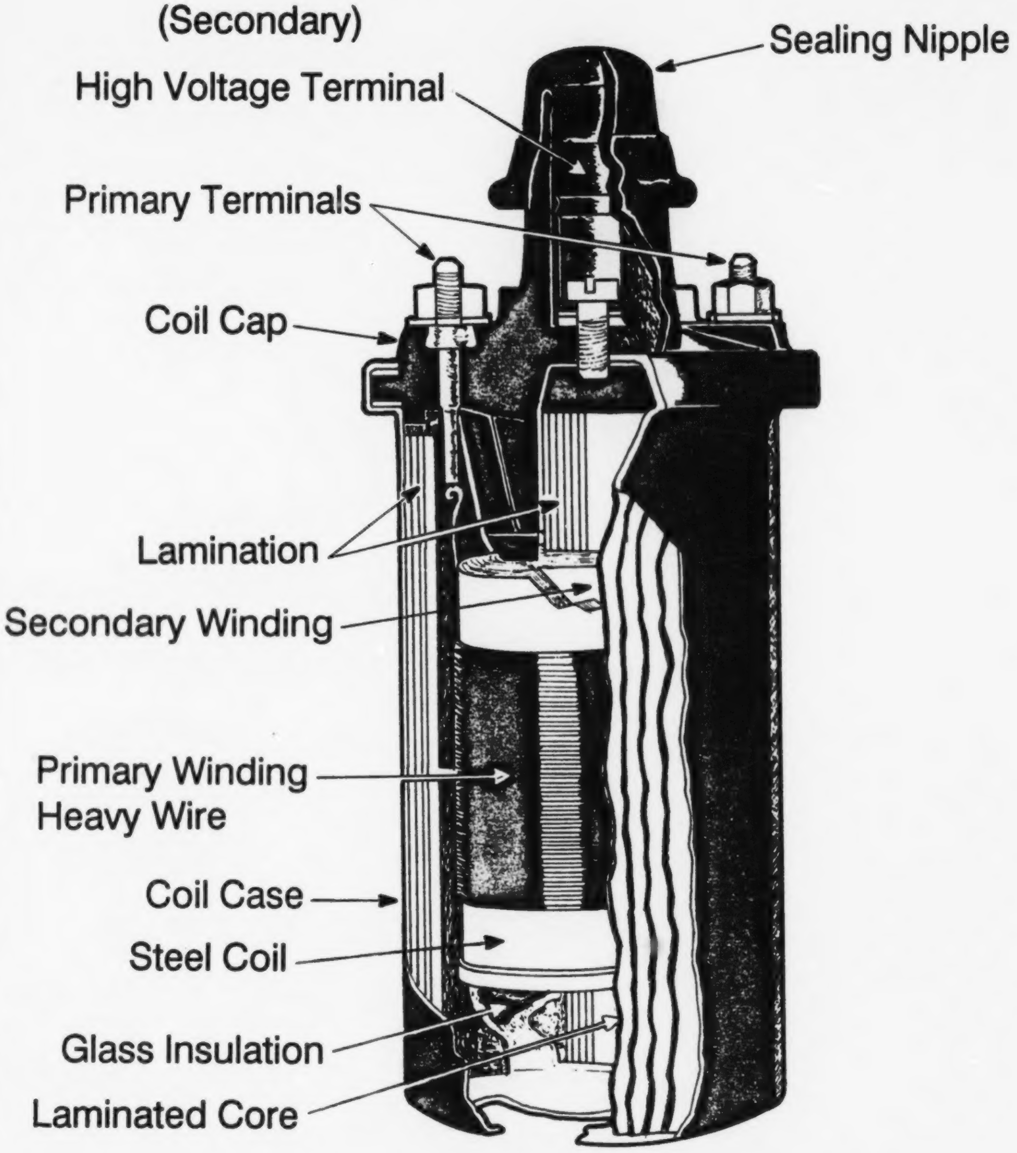
Feeler gauge is a device used for checking the gap on spark plugs or points, measuring in thousandths.

Tachometer is a testing instrument that measures the dwell angle or the number of degrees the distributor can rotate from the time the points open until they close.

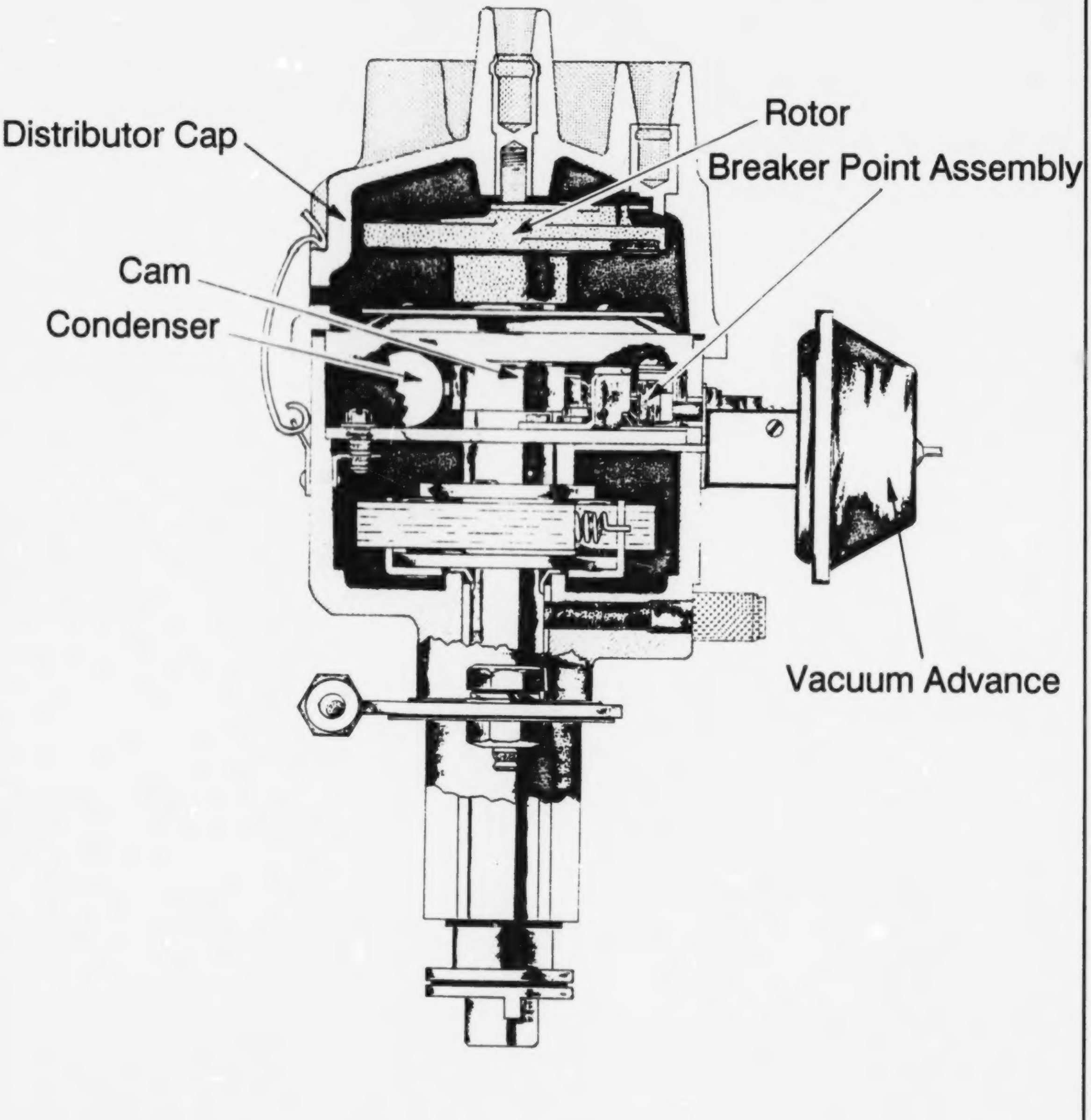
Timing light is a unit connected to the engine ignition system which produces flashes of light in time with the firing of the No. 1 plug.

Voltmeter is an instrument used to measure volts in a circuit.

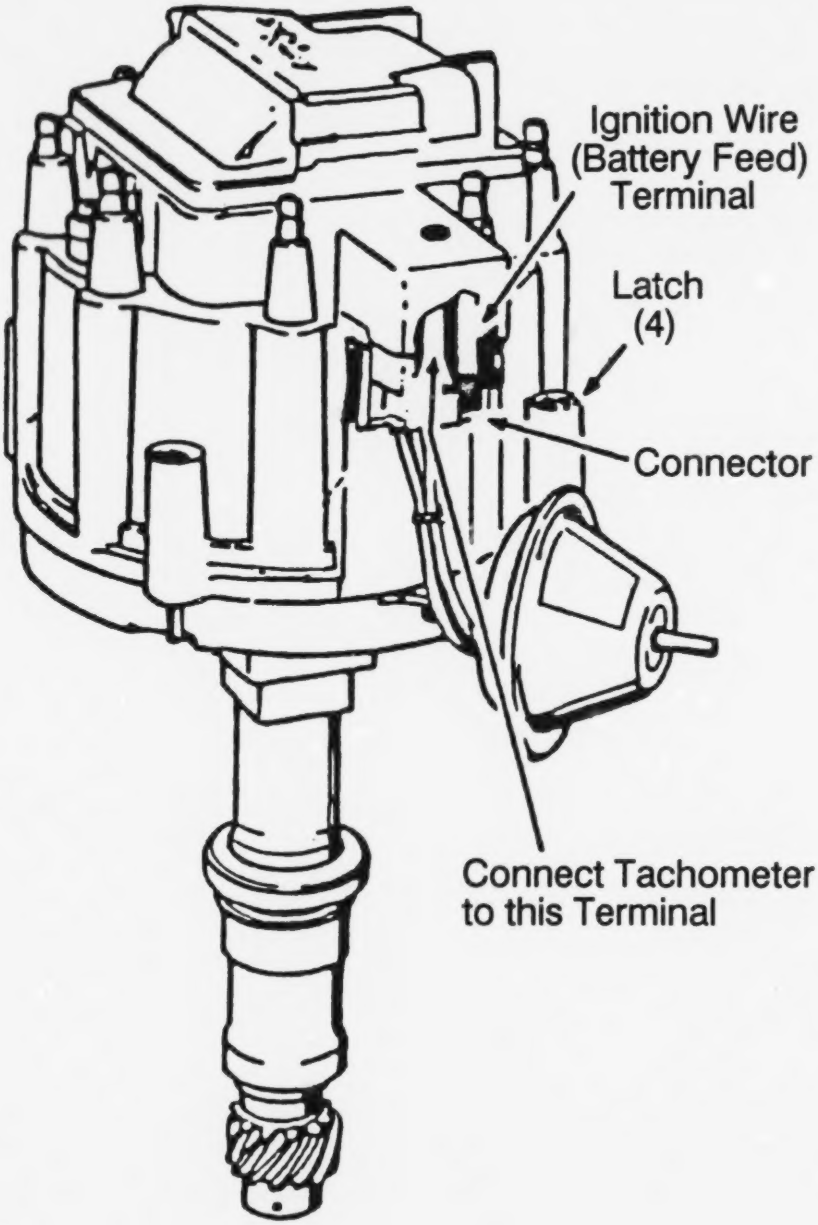
Cutaway View of a Coil

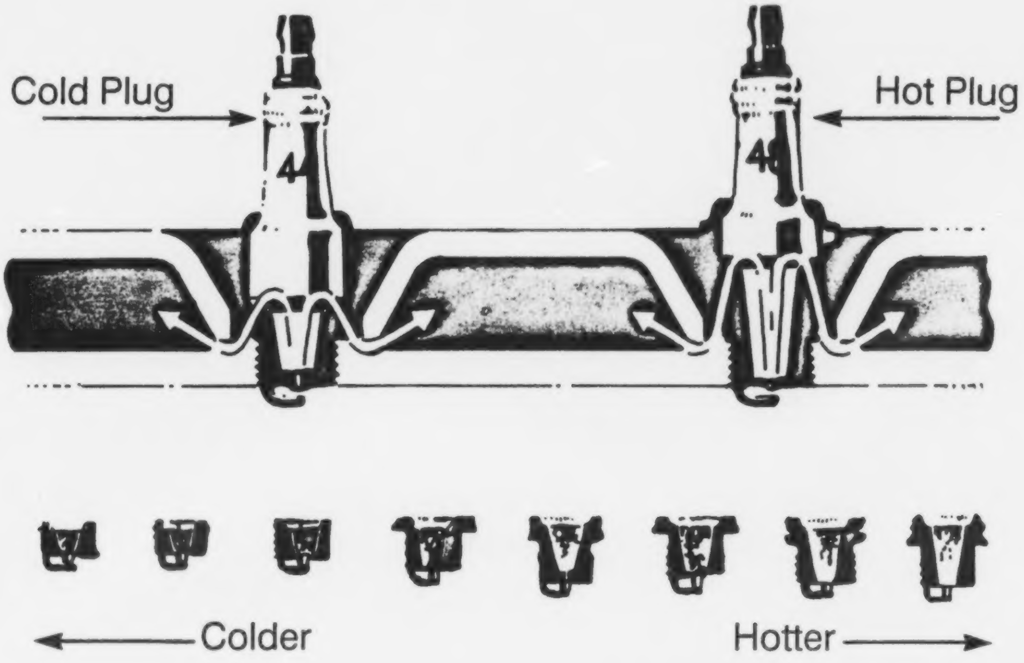

(Secondary)
High Voltage Terminal
Sealing Nipple
Primary Terminals
Coil Cap
Lamination
Secondary Winding
Primary Winding
Heavy Wire
Coil Case
Steel Coil
Glass Insulation
Laminated Core

Cutaway View of Distributor


Distributor Cap
Rotor
Breaker Point Assembly
Cam
Condenser
Vacuum Advance

Tachometer Connection for the HEI System


Ignition Wire
(Battery Feed)
Terminal
Latch
(4)
Connector
Connect Tachometer
to this Terminal

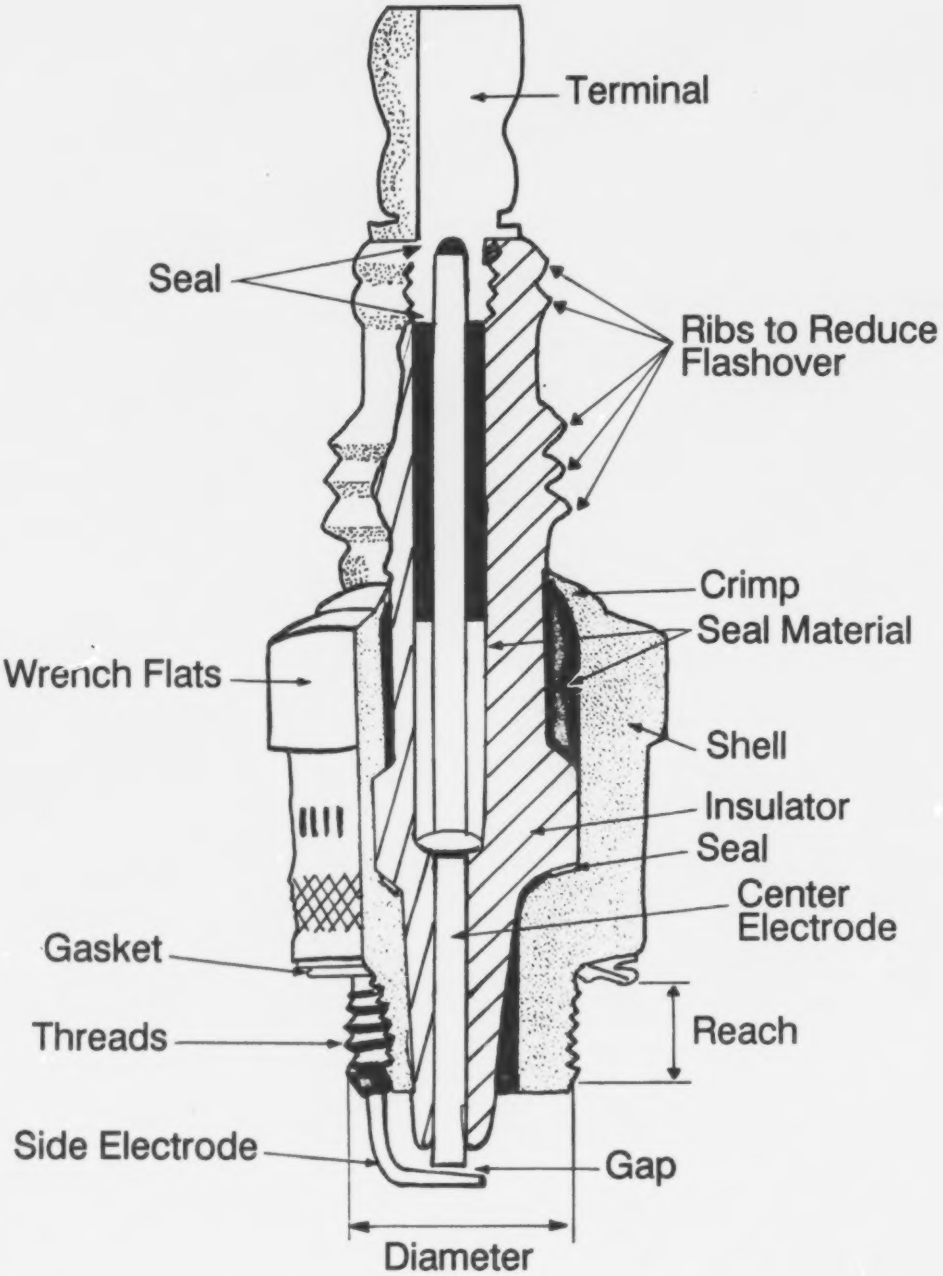

Cold Plug
Hot Plug
Colder
Hotter

Spark plug heat range system. The higher the number the hotter the plug

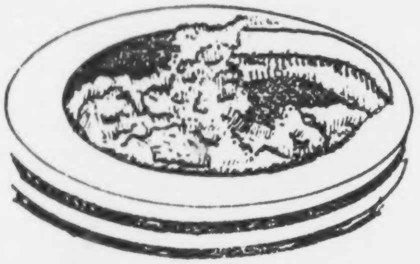
1 2 3 4 5
R 4 5 T S X

1 - R—Indicates Resistor-Type Plug
2 — "4" Indicates 14 mm Threads
3 — Heat Range
4 — TS—Tapered Seat
S—Extended Tip
5 — Special Gap

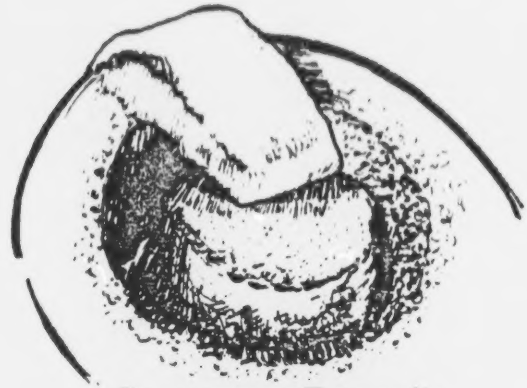
Cutaway View of a Spark Plug


Terminal
Seal
Ribs to Reduce Flashover
Crimp
Seal Material
Wrench Flats
Shell
Insulator
Seal
Center Electrode
Gasket
Reach
Threads
Side Electrode
Gap
Diameter

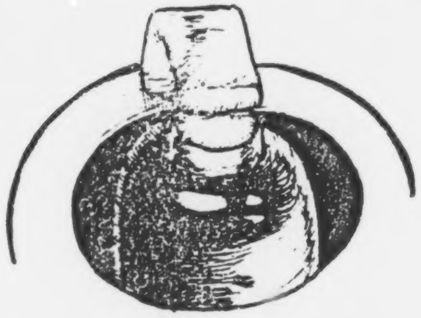
Spark Plug Fouling



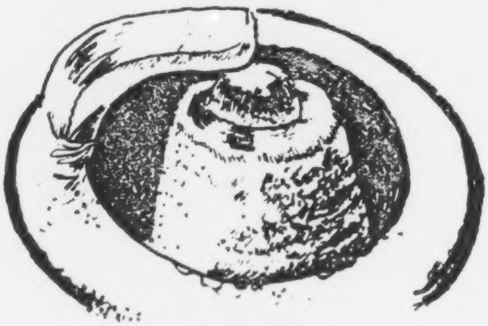
Aluminum Throwoff



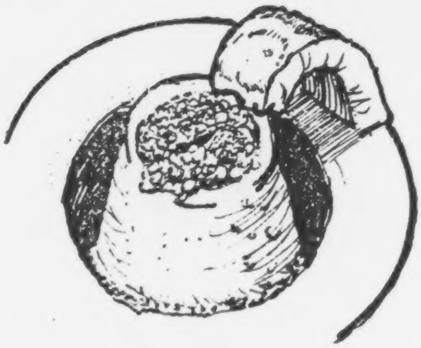
Scavenger Deposits



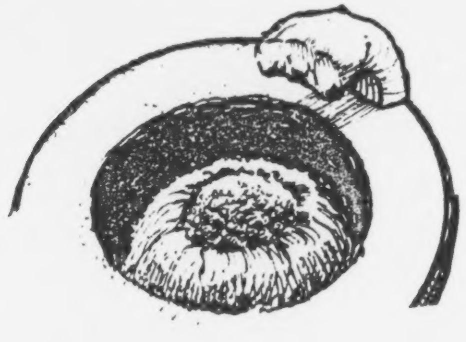
High-Speed Glazing



Overheating



Pre-Ignition



Pre-Ignition Advanced Stage

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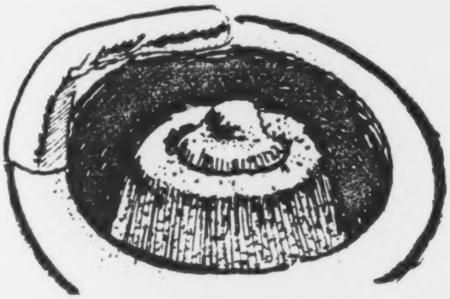
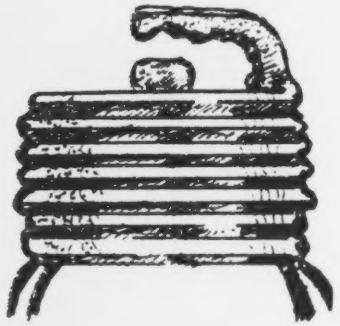
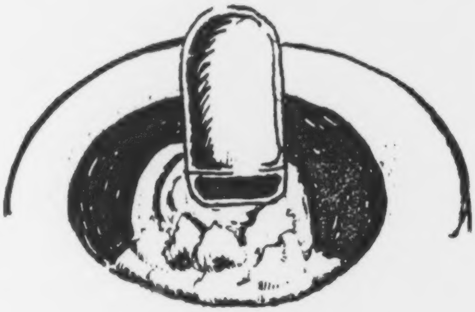
Spark Plug Fouling



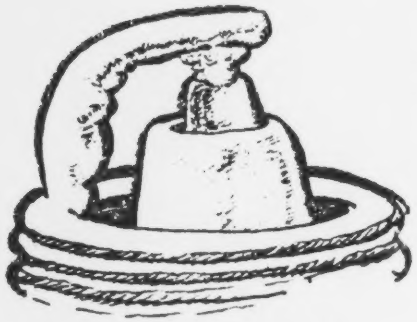
Turbulence Burning



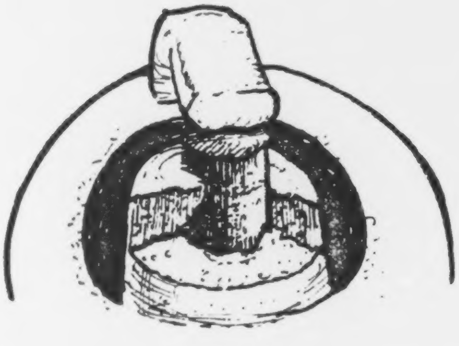
Reversed Coil Polarity



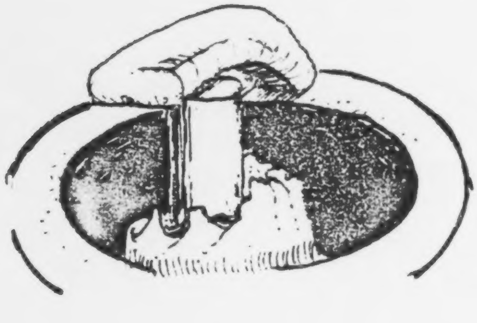
Shell Bridging



Gap Bridging

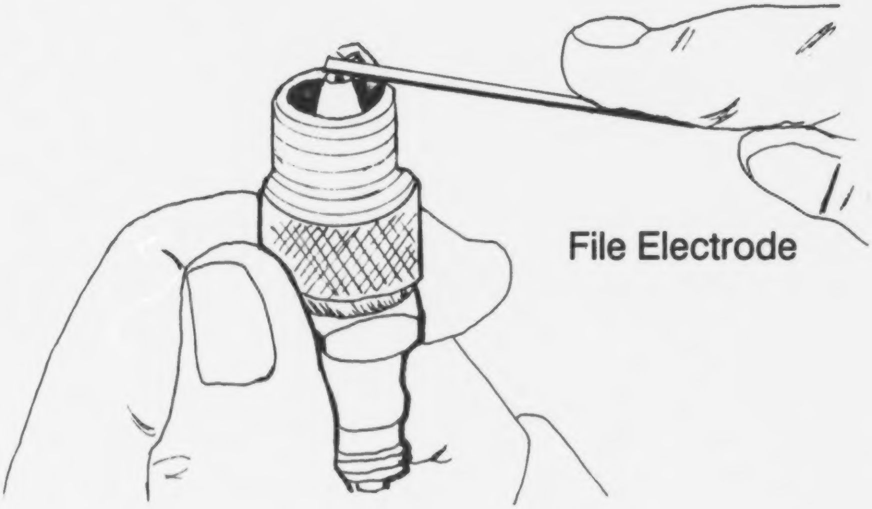


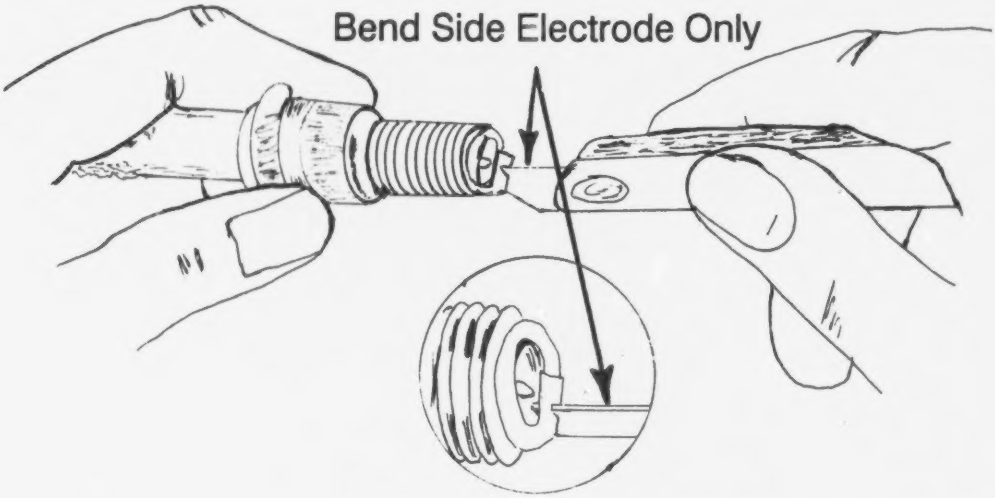
Chipped Insulator



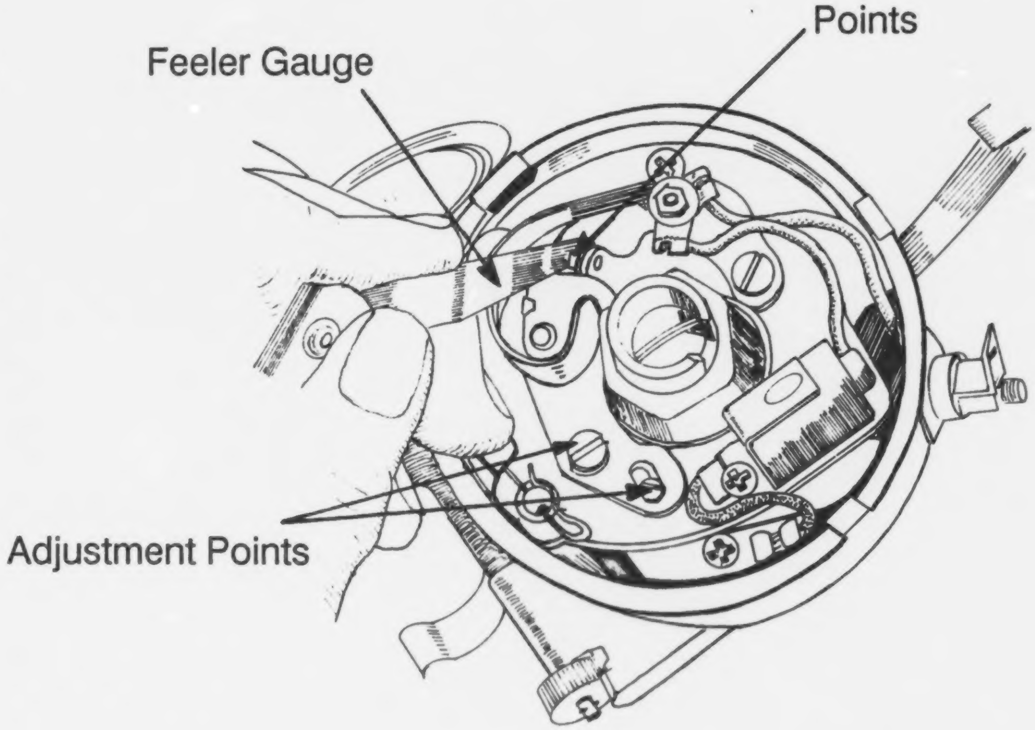
Mechanical Damage

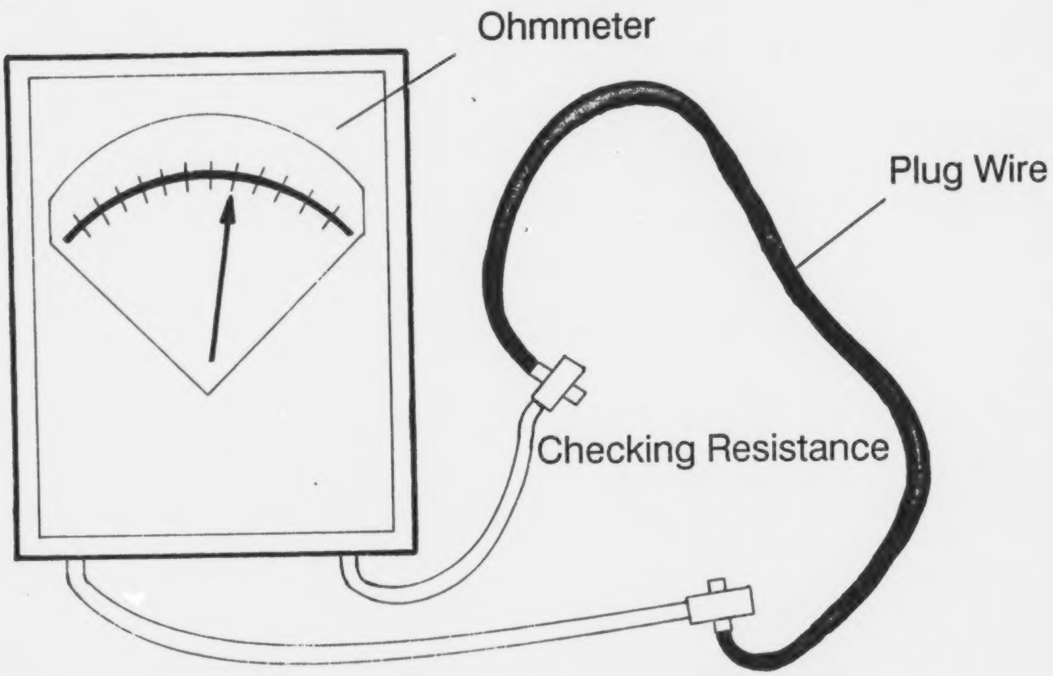
Servicing Spark Plugs


File Electrode

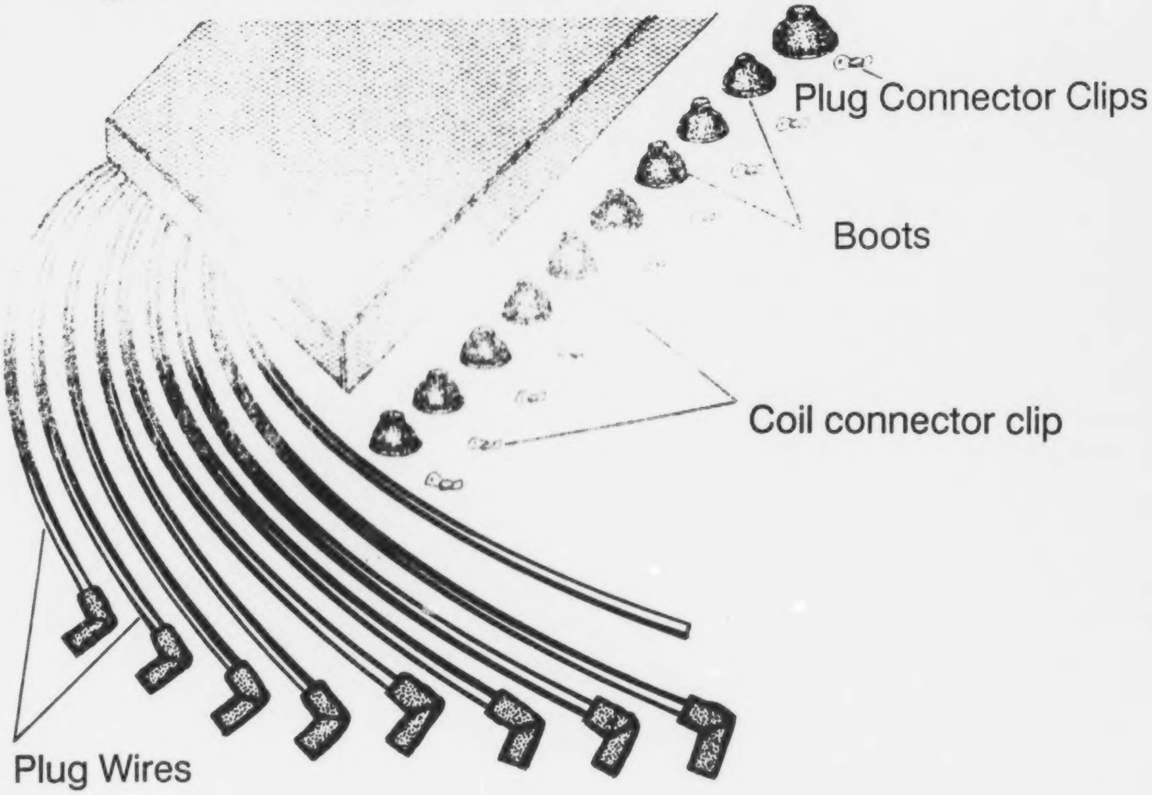

Bend Side Electrode Only

Servicing Breaker Points


Points
Feeler Gauge
Adjustment Points

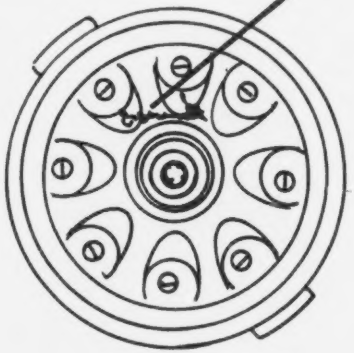

Ohmmeter
Plug Wire
Checking Resistance

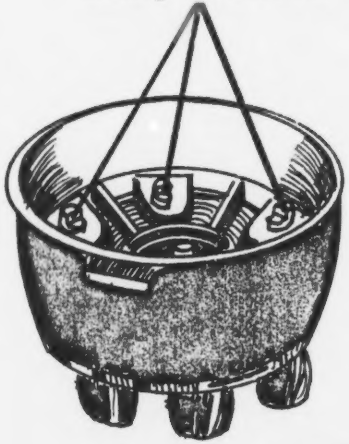
Spark Plug Wires

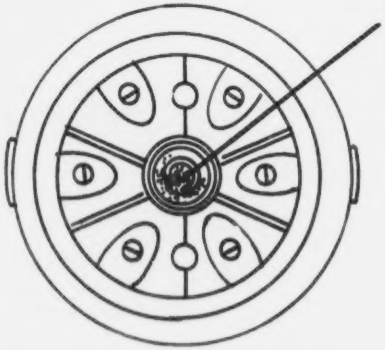

Plug Connector Clips
Boots
Coil connector clip
Plug Wires

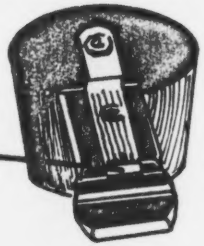
Distributor Cap

(Check Points)

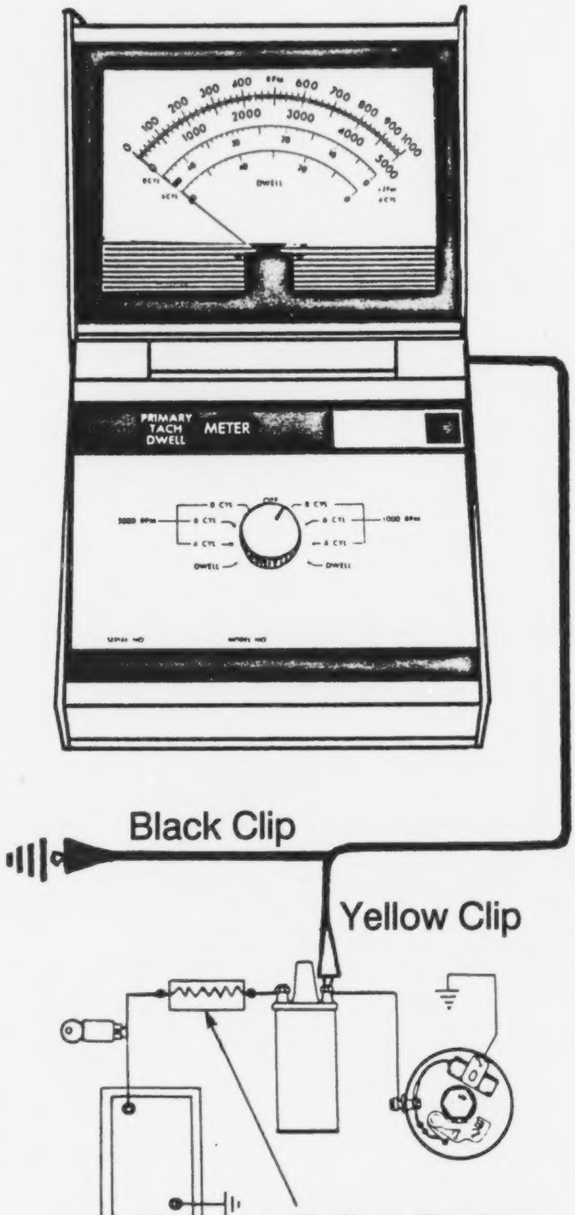

Carbon Tracking


Terminal Posts
Badly Grooved

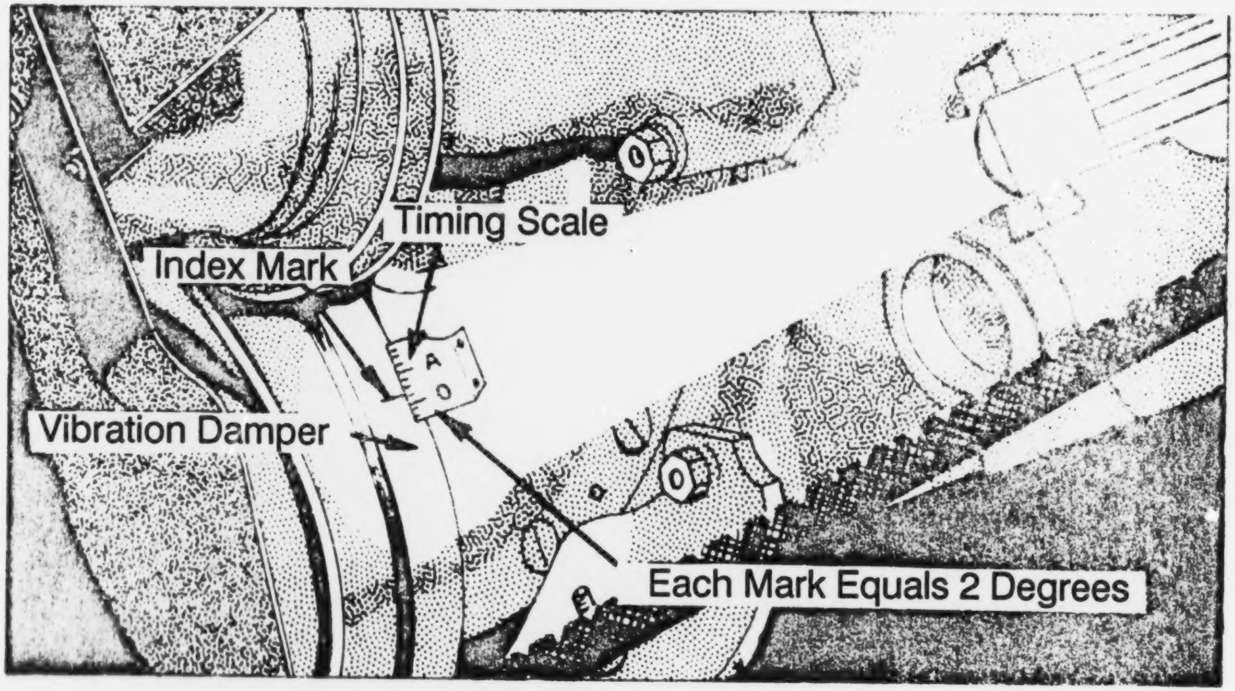

Rotor Contact
Burned Away



Tachometer Connected to an Engine

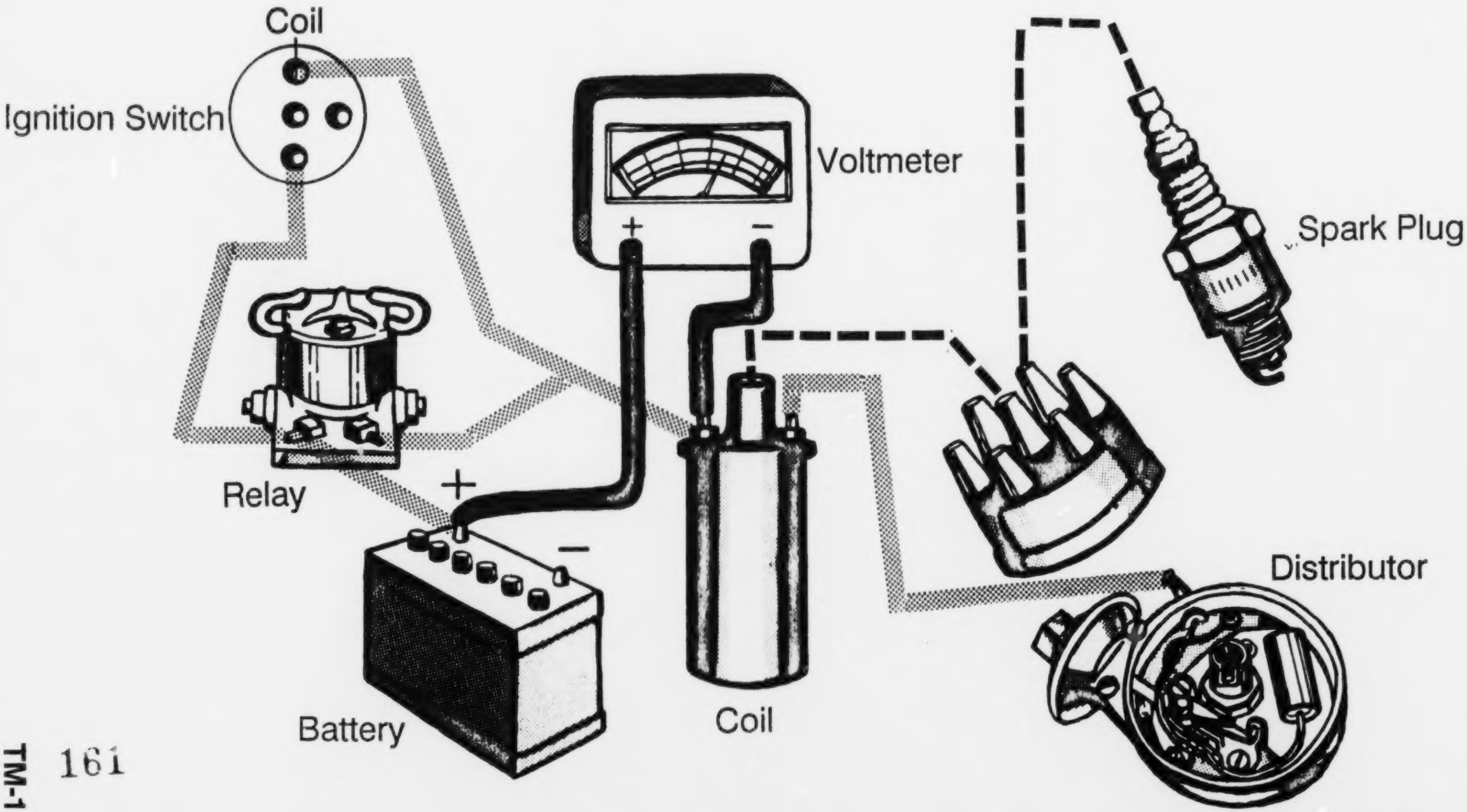

PRIMARY
TACH
DWELL
METER
DWELL
Black Clip
Yellow Clip
Ballast Resistor

Timing


Timing Scale
Index Mark
Vibration Damper
Each Mark Equals 2 Degrees
A
O

Voltmeter

Primary Voltage Test


Coil
Ignition Switch
Voltmeter
+
−
Spark Plug
Relay
+
−
Distributor
Battery
Coil

TM-13

161

162

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ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ DATE ____________________

UNIT: Ignition System

TOPIC: Ignition System Terminology

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the ignition system.

2. Match the term to the correct definition associated with the ignition system.

_____a. A storage place for electricity where chemical energy is converted into electrical energy

_____b. The path through which electricity flows

_____c. Current, as supplied by batteries, that flows in one direction only

_____d. A unit located in a wire or circuit to prevent an overload in the electrical system before the wire burns up

_____e. The connection of an electrical unit to the engine or frame to return current to its source

_____f. A term used for high voltage

_____g. Process of setting fire to a fuel in combustion chamber by means of a spark

1. Relay
2. Ohm
3. Resistor
4. Battery
5. Fuse
6. Short circuit
7. Magnet

_____h. Body of metal that has the ability to attract

_____i. The measure of resistance to the flow of electricity

_____j. The fuel-air mixture ignites or burns before it should

_____k. A magnetically operated switch used to make and break the flow of current in a circuit

_____l. A hot wire in the electrical system that has become grounded

_____m. A device placed in a circuit to lower voltage

8. Circuit
9. High tension
10. Pre-igniting
11. DC
12. Ignition
13. Ground

3. Match the term with the correct description of each component of the ignition system.

_____a. A storage place for electricity where chemical energy is converted into electrical energy

_____b. A switch in the cranking circuit of an engine

_____c. The device used for opening and closing all electrical circuits on an automobile

_____d. A resistor made of a wire which will increase or decrease voltage as the heat of the wire changes

_____e. A unit used to step up battery voltage to a point necessary to fire a spark plug

_____f. A unit designed to make and break the main ignition circuit and to distribute resulting high voltage to the proper cylinder at the right time

_____g. A device with two electrodes which provides an air gap for a spark to jump across and ignite fuel-air mixture in the combustion chamber

1. Coil
2. Battery
3. Spark plug
4. Ignition switch
5. Starter relay
6. Distributor
7. Ballast resistor

4. Match the correct term with each of the component parts of the distributor by placing the number of the part in the blank.

_____a. Distributor cap

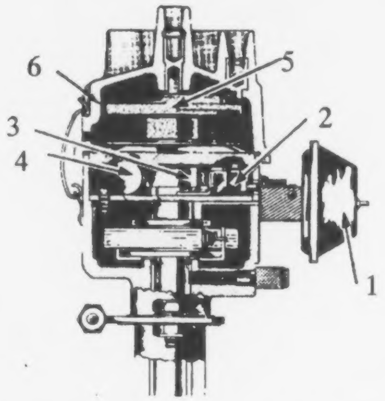
_____b. Rotor

_____c. Cam

_____d. Vacuum advance

_____e. Breaker points

_____f. Condenser



5. Identify the fouling conditions of plugs by placing the correct number in the blanks

_____a. Plug has deposits of black dry carbon which are caused from the plugs being too cold, a high level of fuel in the carburetor, excessive choking, or a clogged air cleaner

_____b. Plugs are covered with wet, black deposits caused by an excessive amount of oil reaching the combustion chamber

_____c. New plugs coated with splashes of carbon deposits because the plugs were installed in an engine that had heavy deposits of carbon in the combustion chamber

_____d. A plug fouled with particles of molten aluminum, caused by the piston breaking up due to rapid combustion, pre-ignition, or over-advanced ignition timing

_____e. A plug with a large piece of piston or combustion chamber deposit sticking between the hot insulator and plug shell

_____f. A plug with carbon-lead deposits connecting the two electrodes

1. Gap bridging
2. Aluminum throw-off
3. Shell bridging
4. Oil fouling
5. Fuel fouling
6. Splashed fouling
7. High-speed glazing

_____g. **A plug with a hard, shiny, yellowish-tan deposit, caused by a sudden increase in plug temperatures during hard acceleration or loading**

6. Match the correct testing equipment with the function of each by placing the number in the blanks.

_____a. A device for checking the gap on spark plug or points, measuring in thousandths

_____b. A testing instrument that measures the number of degrees the distributor cam rotates from the time the points open until they close

_____c. A unit that is connected to the engine ignition system which produces flashes of light in time with the firing of the No. 1 spark plug

_____d. An instrument used to measure volts in any circuit

1. Timing light
2. Dwell meter
3. Voltmeter
4. Feeler gauge

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Ignition System

TOPIC: Change Spark Plugs

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to change spark plugs correctly.

TOOLS AND EQUIPMENT:

Proper size socket
Ratchet drive
Extension (if required)
Thickness gauge
Torque wrench
Auto manual
Fender cover
New spark plugs

GENERAL INSTRUCTIONS: Follow procedures to remove and replace spark plugs

PROCEDURES AND/OR TASKS: **Note:** *1. Follow all safety rules.*
2. To prevent crosswiring, remove and install one spark plug at a time.

1. Install fender cover.

2. Wearing goggles, blow any dirt from the base of each plug with compressed air.

3. Starting with spark plug #1, grasp the plug boot, and twist back and forth to break it free. Once free, pull the boot and plug wire straight off the spark plug. **Hold the boot and not the wire.**

4. Remove spark plug, and keep them in order of removal, so that any unusual plug condition may be related to its cylinder.

5. As each plug is removed, examine it for cylinder conditions such as fuel fouling, oil fouling, shell fouling, and overheating.
6. Check auto manual to be sure the number on the new plugs is the right one for that specific engine.
7. Check the gap on the new plugs and set according to engine type, as specified in the auto manual.
8. Install new plugs in engine, and torque to the correct amount.
9. Reinstall spark plug wire.
10. Have instructor check work.
11. Replace tools and equipment.
12. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT:	Ignition System
TOPIC:	Change Breaker Points and Condenser
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to change the breaker points and condenser correctly.
TOOLS AND EQUIPMENT:	Common screwdriver Thickness gauge Fender cover Dwell meter Allen wrench set New breaker points and condenser Auto manual
GENERAL INSTRUCTIONS:	Follow procedures listed below to remove and replace breaker points and condenser properly.
PROCEDURES AND/OR TASKS:	**Note:** *Follow all safety rules.*

1. Install fender cover.
2. Remove distributor cap.

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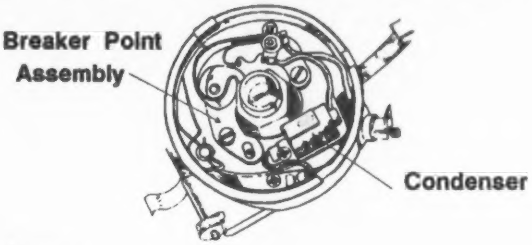
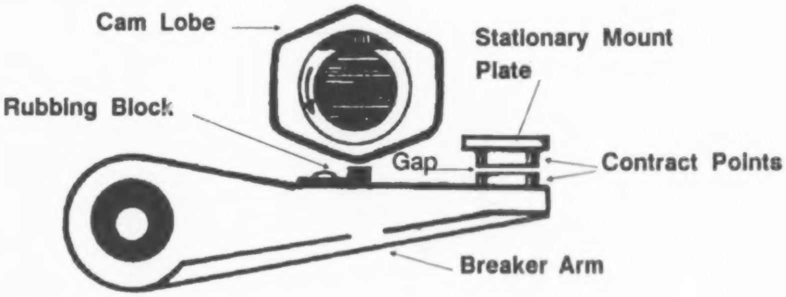
3. Loosen and remove screws holding breaker points and breaker point assembly.


Breaker Point Assembly
Condenser

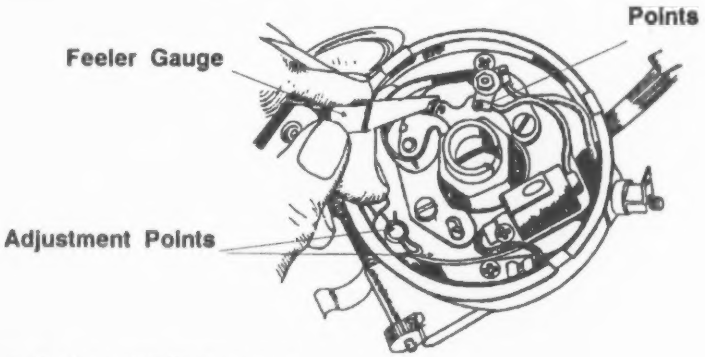
4. Remove the condenser
   Note: *The condenser should be replaced when replacing breaker points.*

5. Install new breaker points and condenser.
   Note: *Be sure points are properly aligned.*

6. Set breaker points rubbing block on highest tip of the cam lobes.


Cam Lobe
Stationary Mount Plate
Rubbing Block
Gap
Contract Points
Breaker Arm

7. Set breaker points to the correct gap, using the thickness gauge according to the auto manual or engine decal.


Points
Feeler Gauge
Adjustment Points

8. Install the distributor cap.

9. Put car in neutral and set parking brake.

170

10. Start car and let the engine run. To check for correct point gap, connect the dwell meter per instructions. The dwell should be within the specs given in the auto manual. If dwell is outside these limits, readjust points.

11. Have instructor check work.

12. Replace tools and equipment.

13. Clean work area.

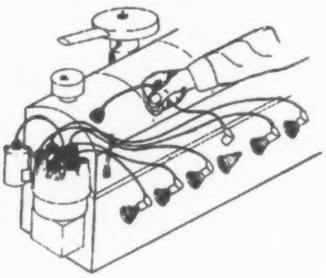
JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT:	Ignition System
TOPIC:	Change Spark Plug Wires
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to change spark plug wires.
TOOLS AND EQUIPMENT:	Fender cover New plug wires
GENERAL INSTRUCTIONS:	Follow procedures to remove and replace spark plug wires.
PROCEDURES AND/OR TASKS:	**Note:** *Follow all safety rules.*

1. Install fender cover.
2. Remove the longest spark plug wire from the engine.



172

3. Remove the longest plug wire from the new set of wires. Match it to the old one to be sure the lengths are similar. If necessary, install new plug boots on the replacement wires.

4. Install the new plug wire, making sure it is firmly seated on the plug and on the distributor.

5. Working from longest to shortest, repeat the procedure for the remaining plug wires.

6. When all new wires are installed, check the firing order per the auto manual.

7. Put car in neutral and set parking brake.

8. Start engine and allow to run.

9. In a darkened room, check engine for flashover.

10. Have instructor check work.

11. Replace tools and equipment.

12. Clean work area.

II-5-JS-4

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Ignition System

TOPIC: Inspect Distributor Cap

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to inspect the distributor cap.

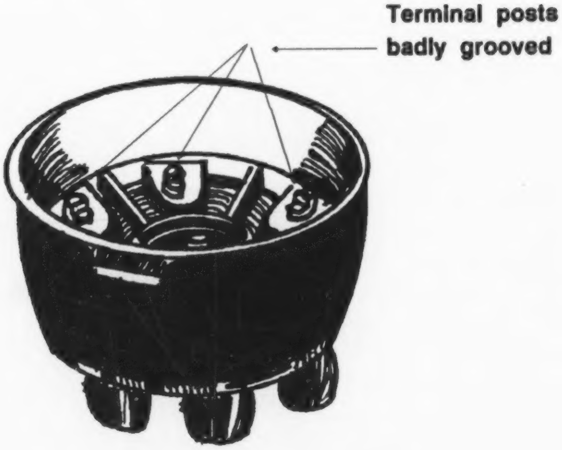
TOOLS AND EQUIPMENT:
Common screwdriver
Fender cover

GENERAL INSTRUCTIONS: Follow procedures to inspect the distributor cap.

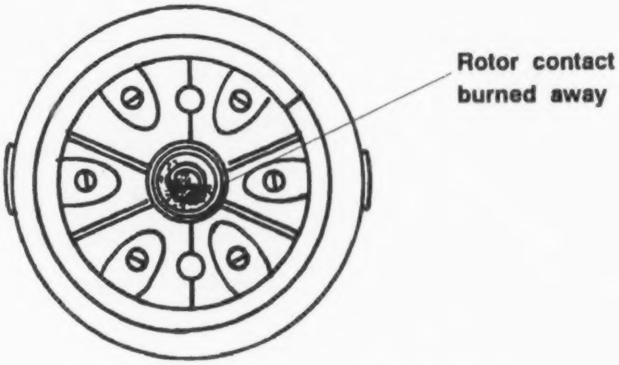
PROCEDURES AND/OR TASKS: **Note:** *Follow all safety rules.*

1. Install fender cover.
2. Remove distributor cap.
   Note: *Remove with screwdriver, if necessary.*
3. Check the cap, looking for moisture, burning, cracks, or flashover.
4. If wires need changing, refer to the previous lesson for the proper procedure.
5. Replace the distributor cap if flashover or carbon tracking has been present.
6. Replace the rotor when replacing the distributor cap.

7. Check the terminal post for burning or scaling.


Terminal posts
badly grooved

8. Check the central carbon button contact for burning or cracking.


Rotor contact
burned away

9. If the distributor cap does not need replacing, clean the original cap with solvent.
10. Dry the cap thoroughly.
11. Replace the distributor cap.
12. Have instructor check work.
13. Replace tools and equipment.
14. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

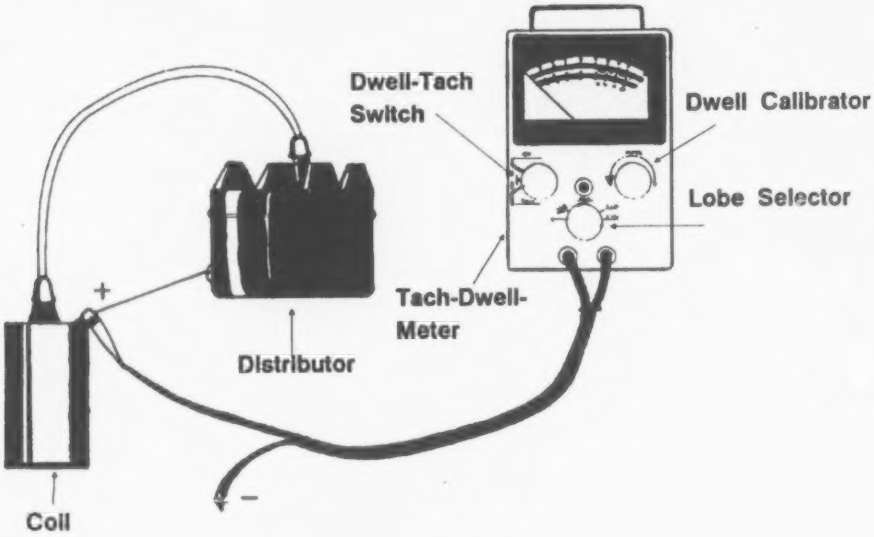
NAME ________________________ DATE ______________

UNIT:	Ignition System
TOPIC:	Using the Tachometer
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to use the tachometer.
TOOLS AND EQUIPMENT:	Dwell Tach Common screwdriver Allen wrench set Auto manual Fender cover
GENERAL INSTRUCTIONS:	Follow procedures to use the tachometer.
PROCEDURES AND/OR TASKS:	**Note:** *Follow all safety rules.*

1. Install fender cover.

2. Turn on dwell meter and calibrate needle.

3. Attach the dwell meter with the red lead to the positive post on the coil and the black lead to any ground.


Dwell-Tach
Switch
Dwell Calibrator
Lobe Selector
Tach-Dwell-
Meter
+
Distributor
Coil
−

4. Place automobile in neutral or park and set the parking brake.

5. Start engine and run at a fast idle, or about 1500 RPM; Set meter to "Dwell," and verify that dwell is correct.

6. Set meter to "Tach," allow engine to return to curb idle. Verify that idle speed is within specs.

7. Have instructor check work. Turn off engine.

8. Replace tools and equipment

9. Clean work area.

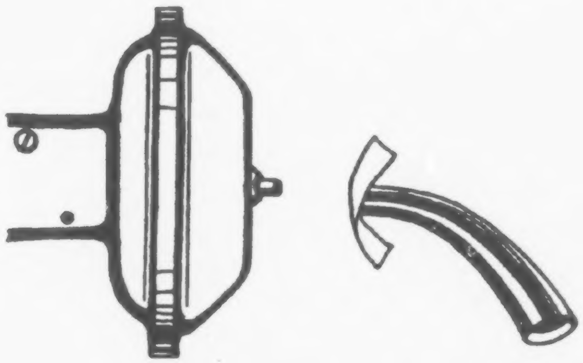
JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

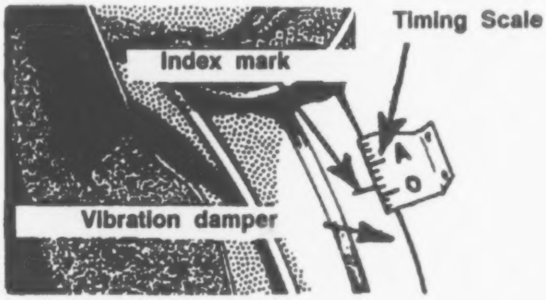
UNIT:	Ignition System	
TOPIC:	Checking the Ignition Timing	
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)	
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to check the ignition timing.	
TOOLS AND EQUIPMENT:	Timing light Chalk	Box-end wrenches Fender cover
GENERAL INSTRUCTIONS:	Follow procedures to check the ignition timing.	
PROCEDURES AND/OR TASKS:	**Note**: *Follow all safety rules.*	

1. Attach the timing light to the engine with the red lead to the positive post on battery, the black lead to the negative post on battery, and the large wire to the #1 engine spark plug wire.



2. Remove the vacuum advance hose and tape the vacuum fitting if recommended in auto manual.

3. Clean off the timing pointer or scale and also the index mark on the vibration damper.


Timing Scale
Index mark
A
O
Vibration damper

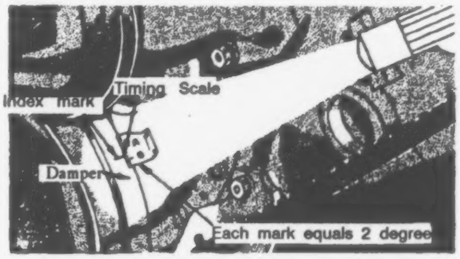
4. Chalk or paint the index line to make it easier to read. Also chalk or paint the correct timing mark on the scale.

5. Place automobile in neutral or park and set the parking brake.

6. Start the engine and idle at recommended RPM.
   Note: *The engine should be at a slow idle.*

7. Direct the timing light beam on the timing marks.

8. If the marks don't line up, loosen the distributor clamp. Rotate the distributor body until the marks are aligned. Tighten the clamp.


Timing Scale
Index mark
Damper
Each mark equals 2 degree

9. Have instructor check work.

10. Turn off engine. Reconnect the vacuum line at the distributor.

11. Replace tools and equipment.

12. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT:	Ignition System
TOPIC:	Using the Voltmeter
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to use the voltmeter.
TOOLS AND EQUIPMENT:	Voltmeter Fender cover
GENERAL INSTRUCTIONS:	Follow procedures to use the voltmeter.
PROCEDURES AND/OR TASKS:	**Note:** *Follow all safety rules.*

1. Set the voltmeter scale to a voltage scale higher than the voltage expected.
   Example:

   If you are expecting a voltage reading of 12 volts, set the meter on the 25-volt scale. Make sure that "DC" voltage is selected. If the meter is set for "AC," the readings will be inaccurate.

2. To read any voltage, attach the meter with the red lead to a power or hot wire and the black lead to a ground.

3. Check and record the following:

   ________ Battery voltage (engine off)

   ________ Battery voltage (engine on, all accessories off)

________ Battery voltage (engine on, all accessories on)

________ Coil voltage

________ Headlight voltage

________ Tail light voltage

________ Stop light voltage

4. After completing the voltage checks, set the current selector on **AC** and the voltage selector on the highest voltage scale before storing the meter.
5. Have instructor check work.
6. Replace tools and equipment.
7. Clean work area.

STUDENT INFORMATION SHEET

MINOR AUTOMOTIVE MAINTENANCE

UNIT: Lubrication System

TOPIC: Lubrication System

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to inspect and service the lubrication system.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will understand the use of lubricants and the lubrication system, identify and service parts as needed.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with the lubrication system include oral and written communications, reading concepts, mathematics and science.*

Term and Definitions

The lubrication system reduces friction by using oil or grease throughout the automobile to make it last longer and operate more economically. Three types of lubricating systems are full pressure, splash oiling, and combination splash and pressure.

Some of the terms and definitions used with the lubrication system are:

Additive is a material or solution added to a mixture to increase efficiency.

Differential is a unit that drives both rear axles, but will allow them to turn at different speeds when making turns.

Dipstick is a metal stick used to measure the oil level in an engine or automatic transmission.

Friction is the resistance to any motion between two surfaces in contact.

Lubricant is any material used to prevent friction between two surfaces.

Several types of lubricants are used. Some of these are:
1. **Motor oil** is used in the engine.
2. **ATF lubricant** is automatic transmission fluid.
3. **Gear oil** is used in some manual transmissions, transfer cases, steering gearboxes and differentials.
4. **Chassis** grease is used on suspension pivot points.

Some of the ways lubricants are broken down are moisture, freezing, excessive heat, wrong type lubricants, length of lubricant use and mixing of oil brand/types.

ML— Motor light oil

MM—Motor medium oil

MS—Motor severe oil

MV—Multi-viscosity of oil

Oil is a by-product of petroleum used for lubrication The five functions of oil are to cool, clean, cushion, lubricate and seal.

Oil bath air cleaner is a unit that uses oil to clean air entering the engine.

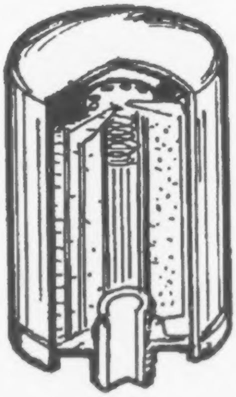
Oil filter is part of the lubrication system used to clean the oil. The typical type of oil filter is the **spin-on** type; however some **canister**-type filters are still in use.

Oil pump is a device used to force oil through the engine.

Oil seal is a device used to prevent oil leakage past a certain point in the engine.

S.A.E.—Society of Automotive Engineers

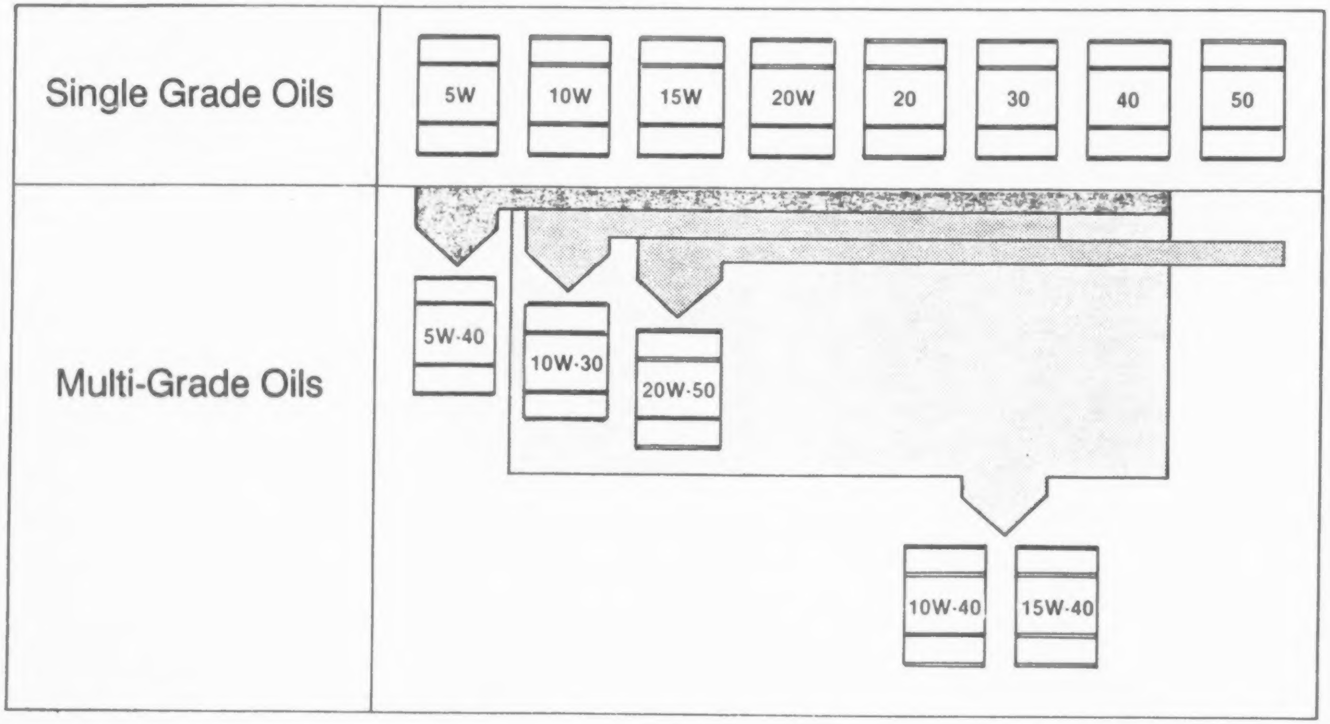
Sump is the part of the engine that holds the oil.



Oil Filter

Comparison of Crankcase Oils

(Viscosity-Grades)



Single Grade Oils

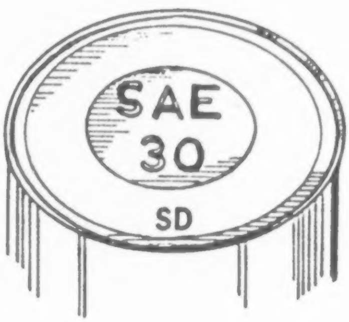
5W
10W
15W
20W
20
30
40
50

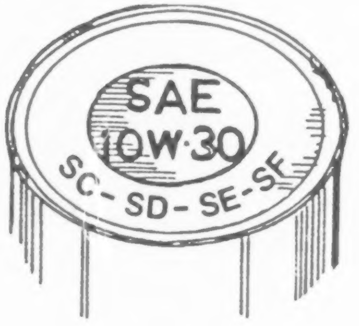
Multi-Grade Oils

5W-40
10W-30
20W-50
10W-40
15W-40

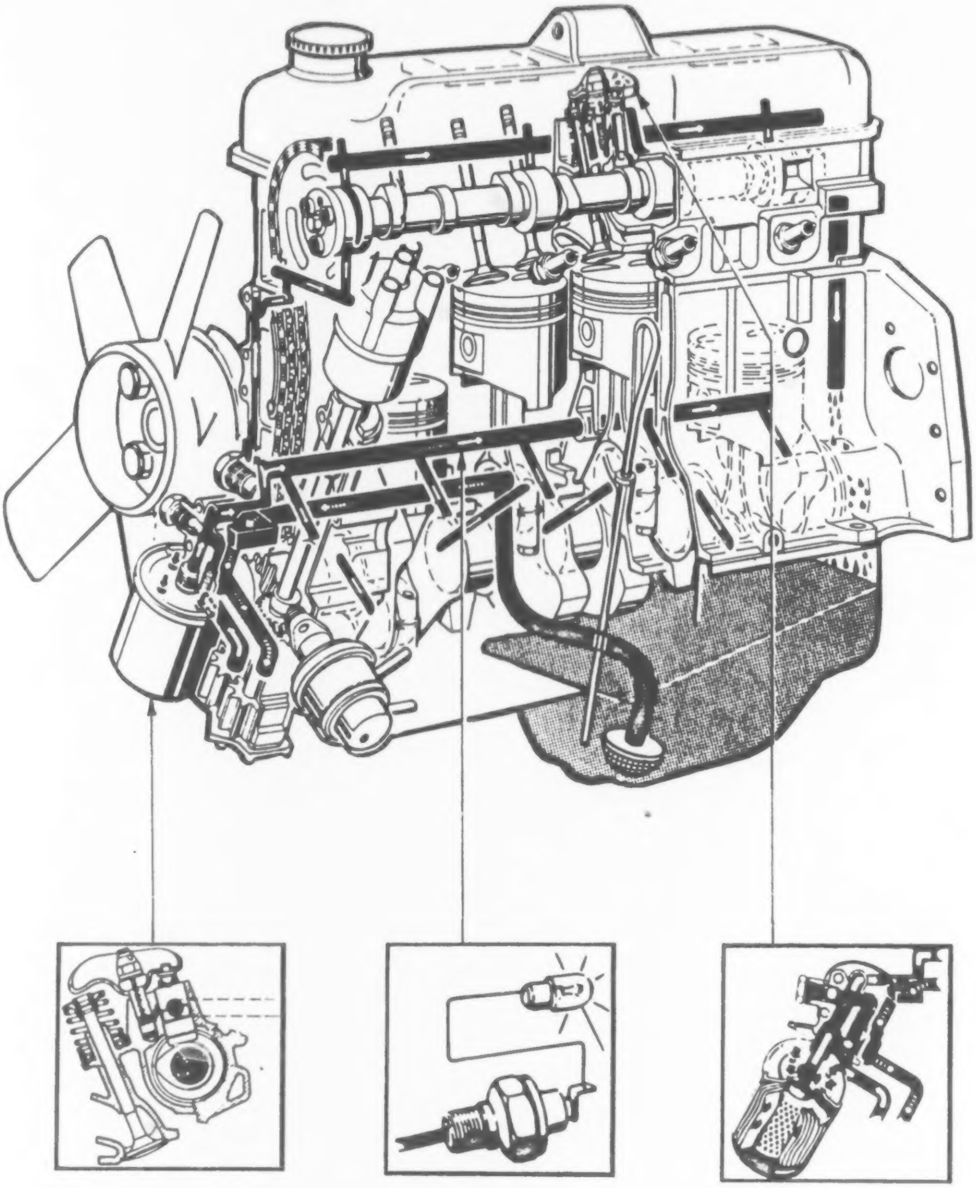
API Classification System

Note: Check operator's manual for recommended oil classification.Use a high quality detergent oil classsified "For Service SC, SD, SE, or SF." Classification markings are on the oil can.




SAE
10W·30
SC- SD- SE-SF

Lubrication System



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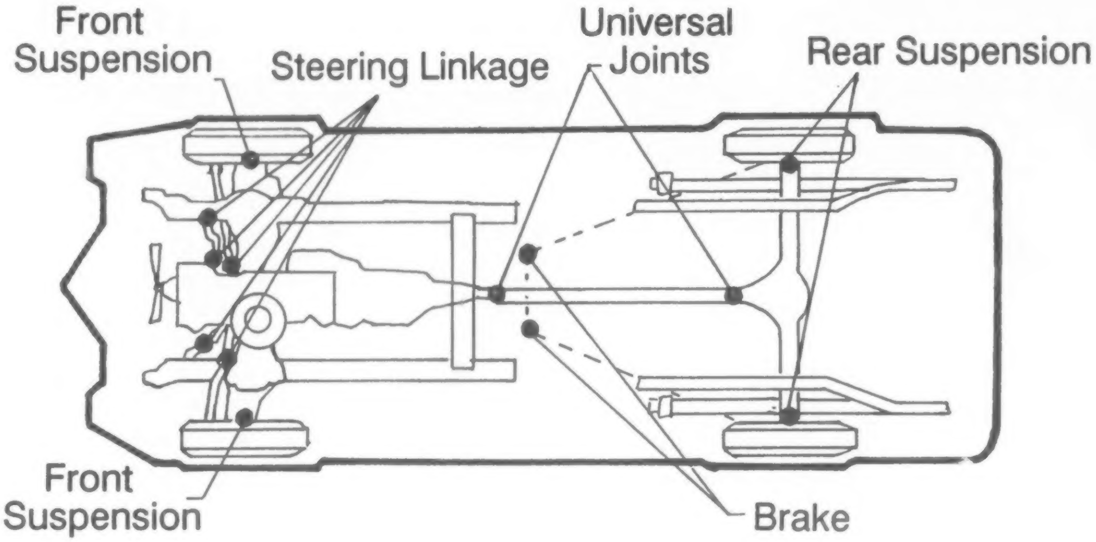
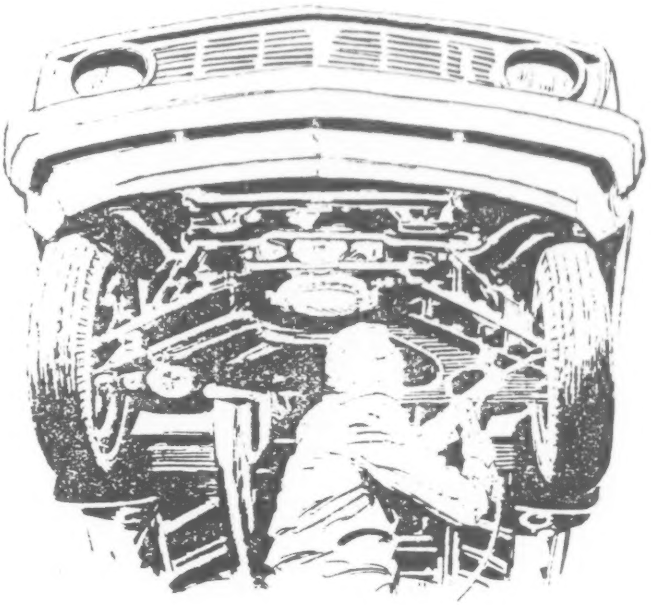
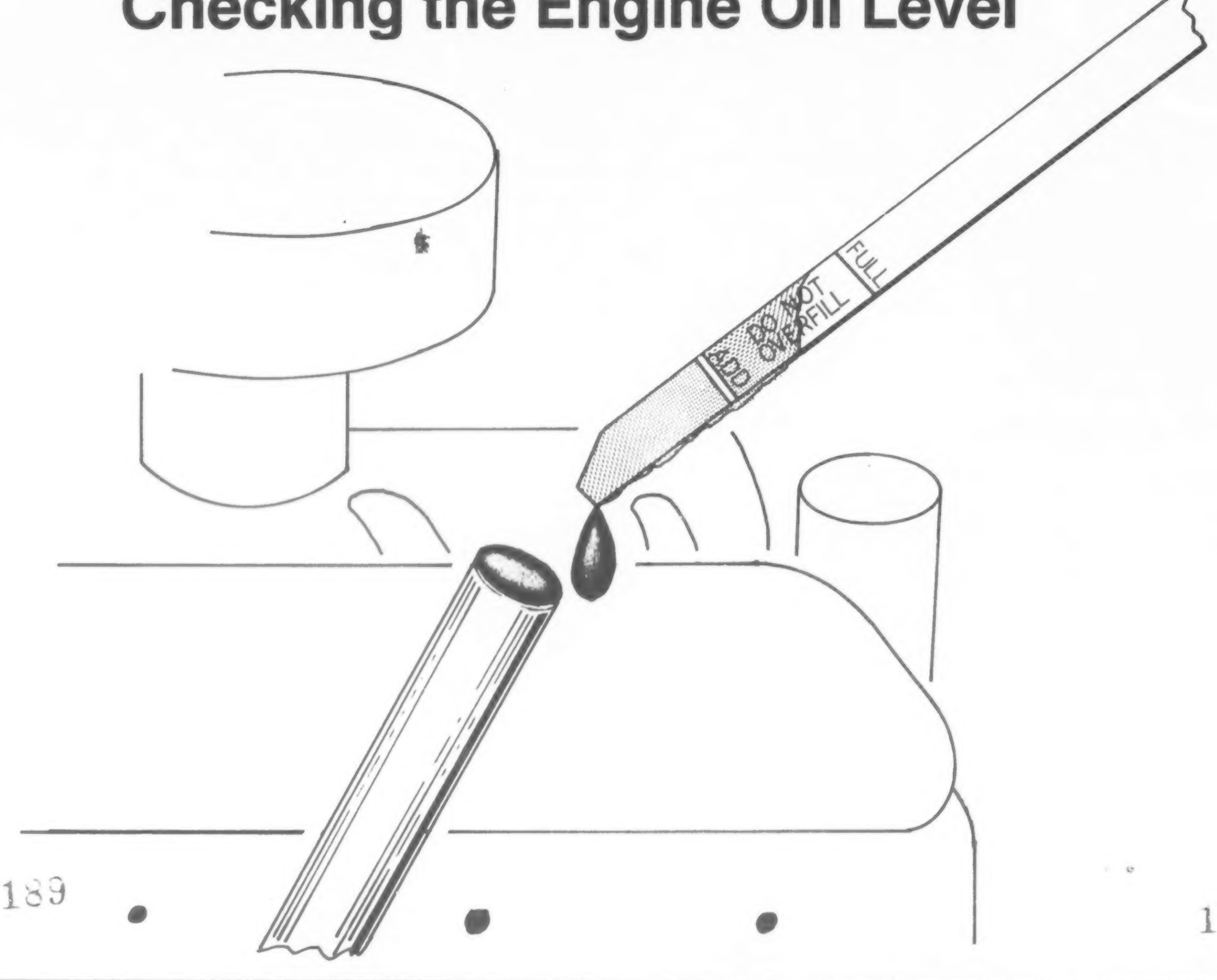
Lubricating the Chassis

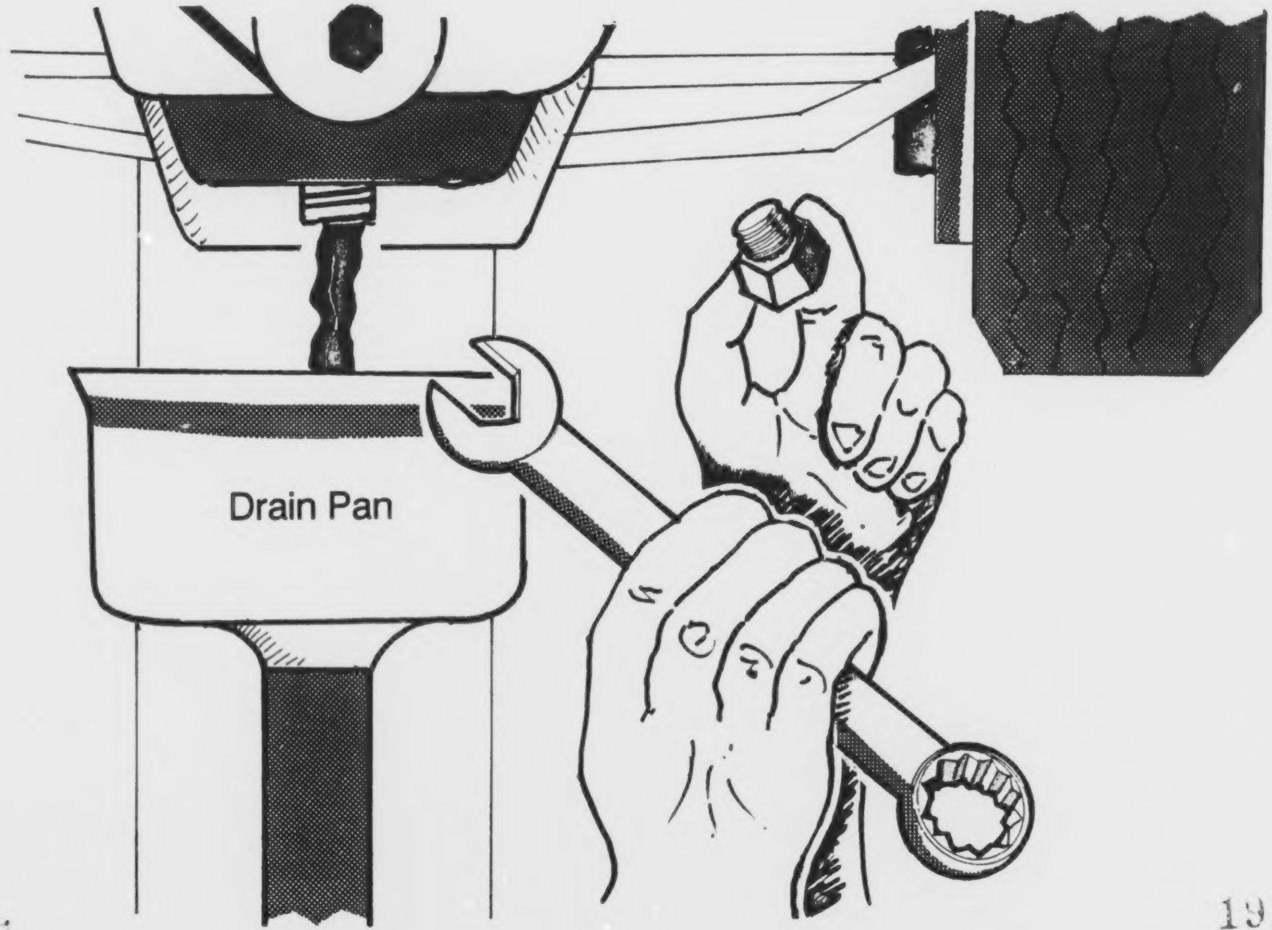

Front Suspension
Steering Linkage
Universal Joints
Rear Suspension
Front Suspension
Brake



Checking the Engine Oil Level

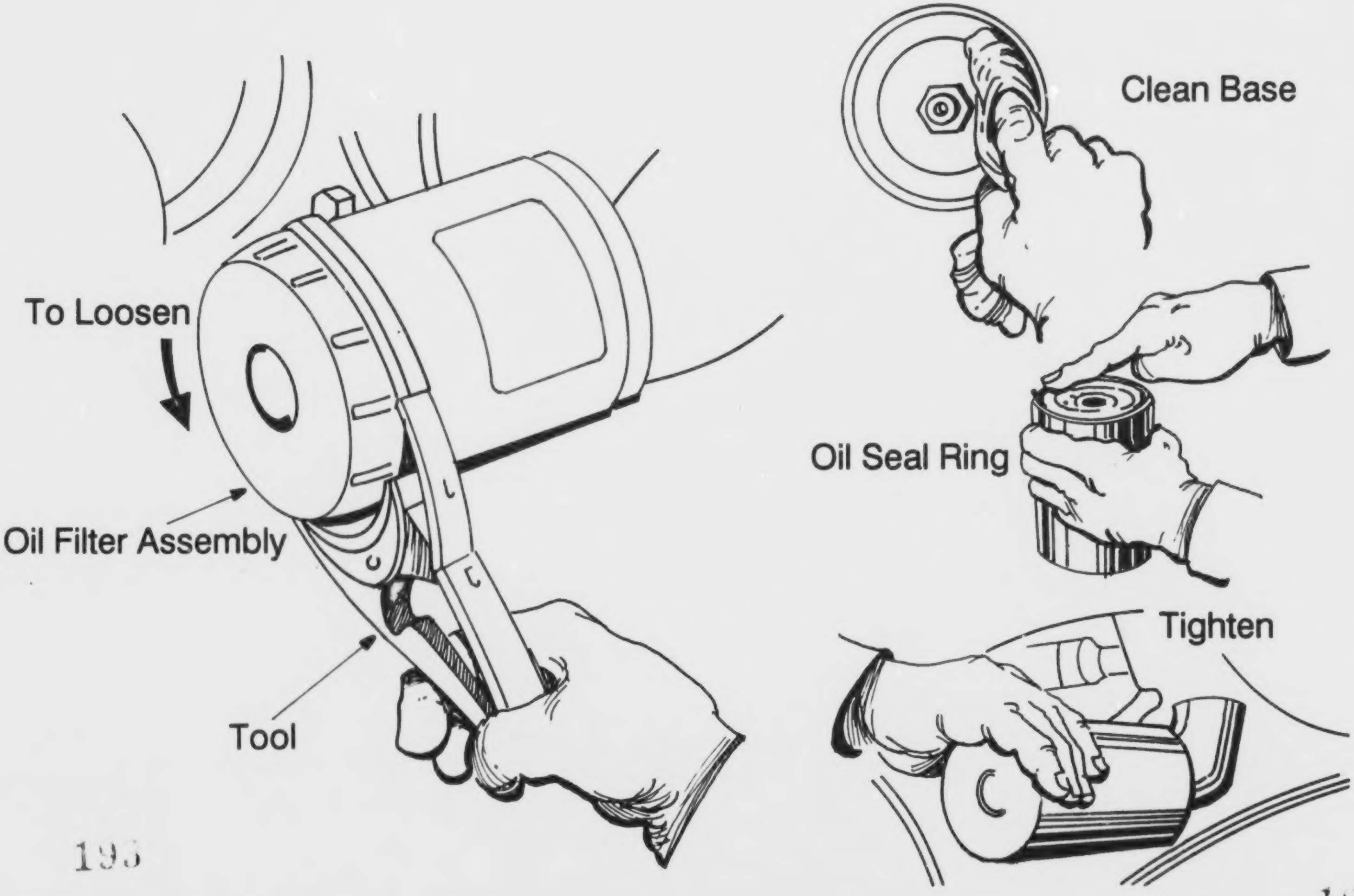

ADD
DO NOT OVERFILL
FULL

Changing the Engine Oil

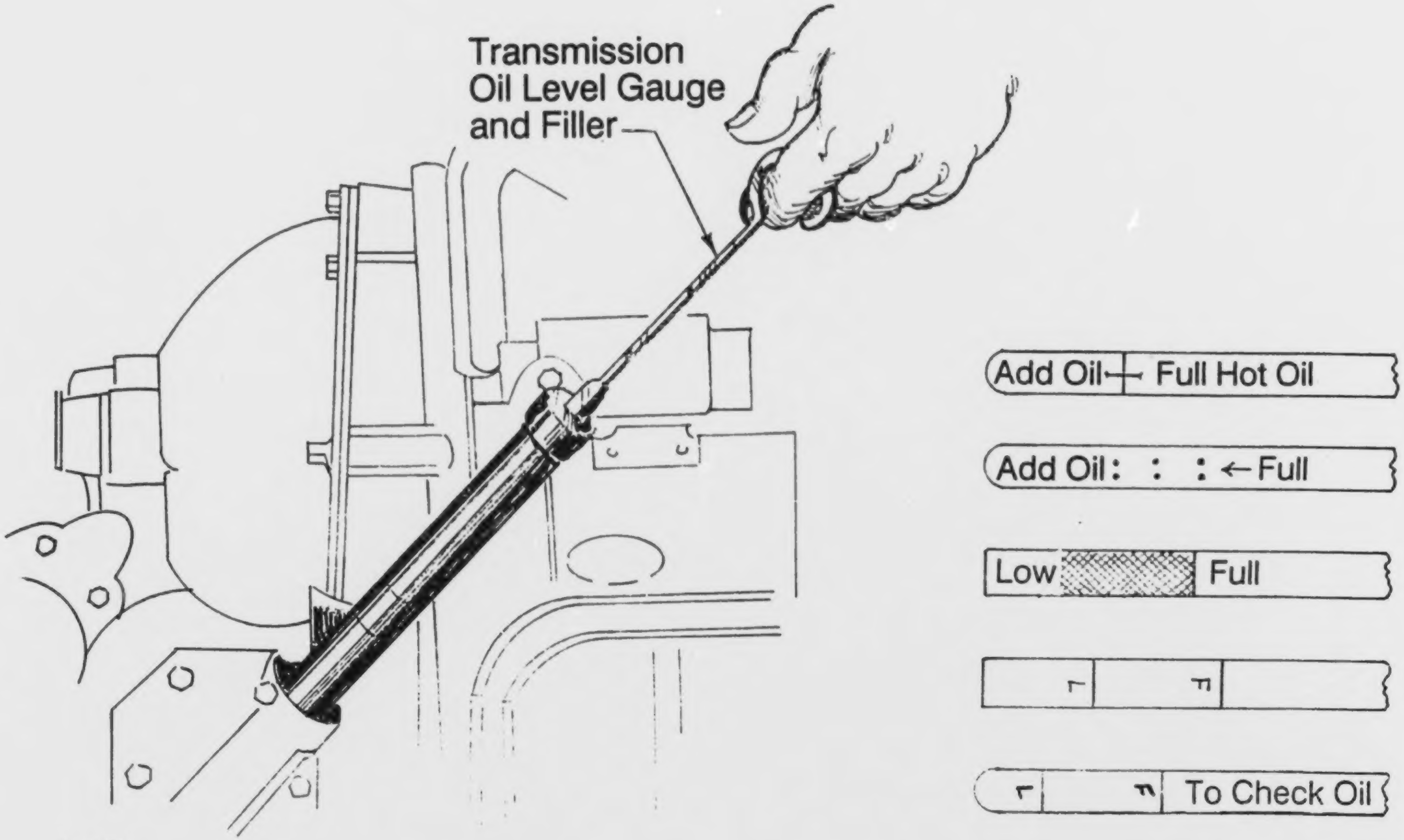


TM-6

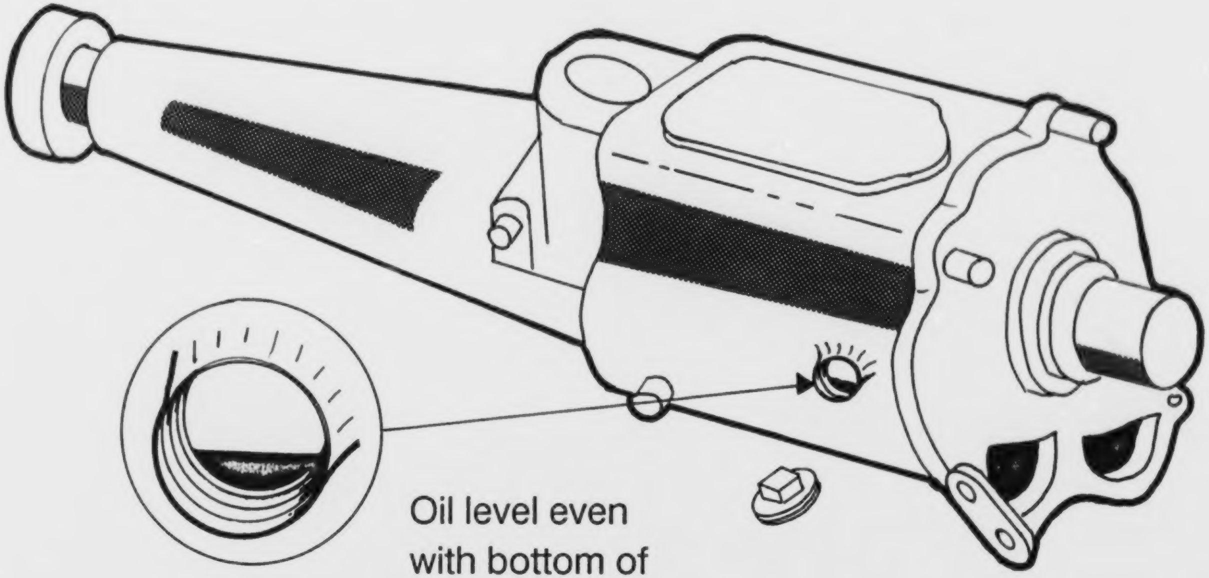
Changing the Engine Oil Filter


Clean Base
To Loosen
Oil Seal Ring
Oil Filter Assembly
Tighten
Tool

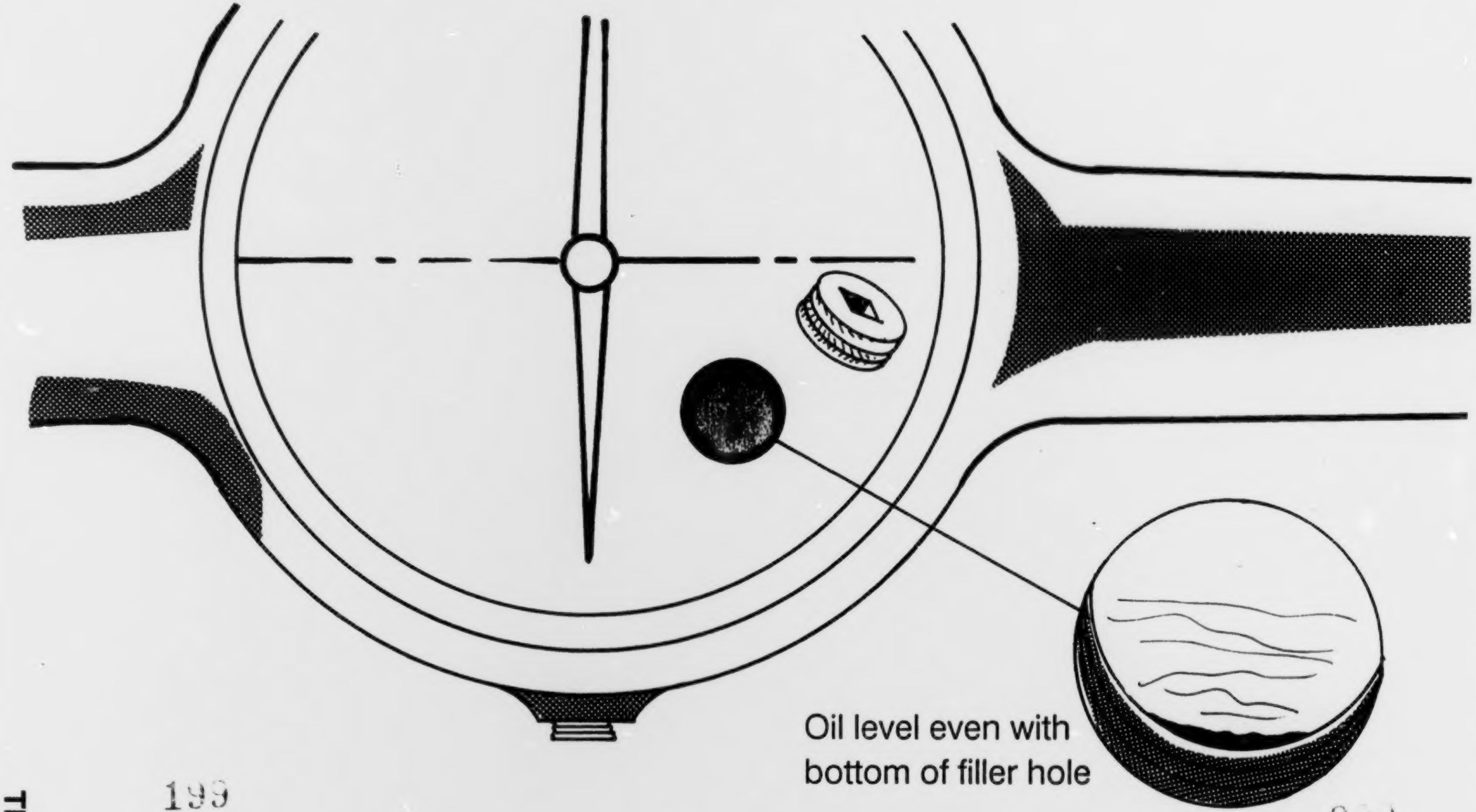
Checking the Oil Level of an Automatic Transmission


Transmission Oil Level Gauge and Filler
Add Oil
Full Hot Oil
Add Oil
Full
Low
Full
L
F
L
F
To Check Oil

Checking the Level in a Standard Transmission


Oil level even
with bottom of
filler hole

Checking the Oil Level of the Differential

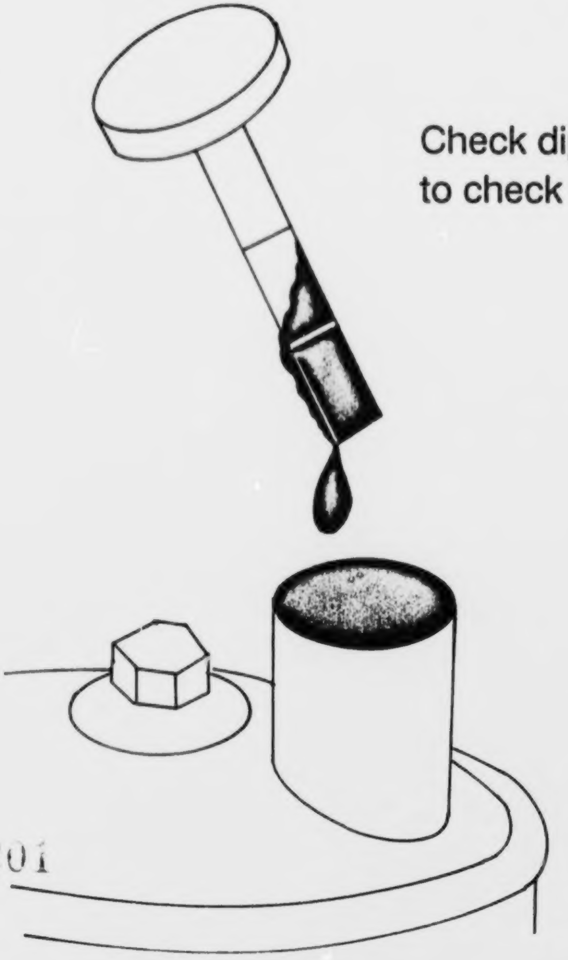


Oil level even with bottom of filler hole

TM-10

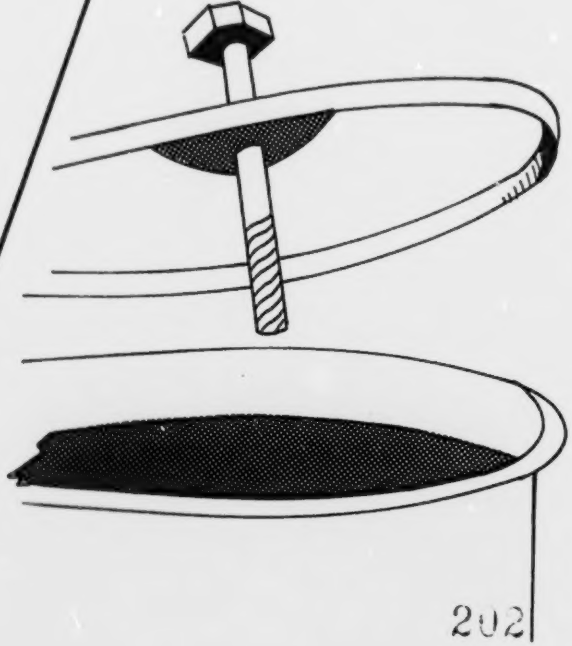
Checking the Oil in a Power Steering Pump

Check dipstick
to check oil level



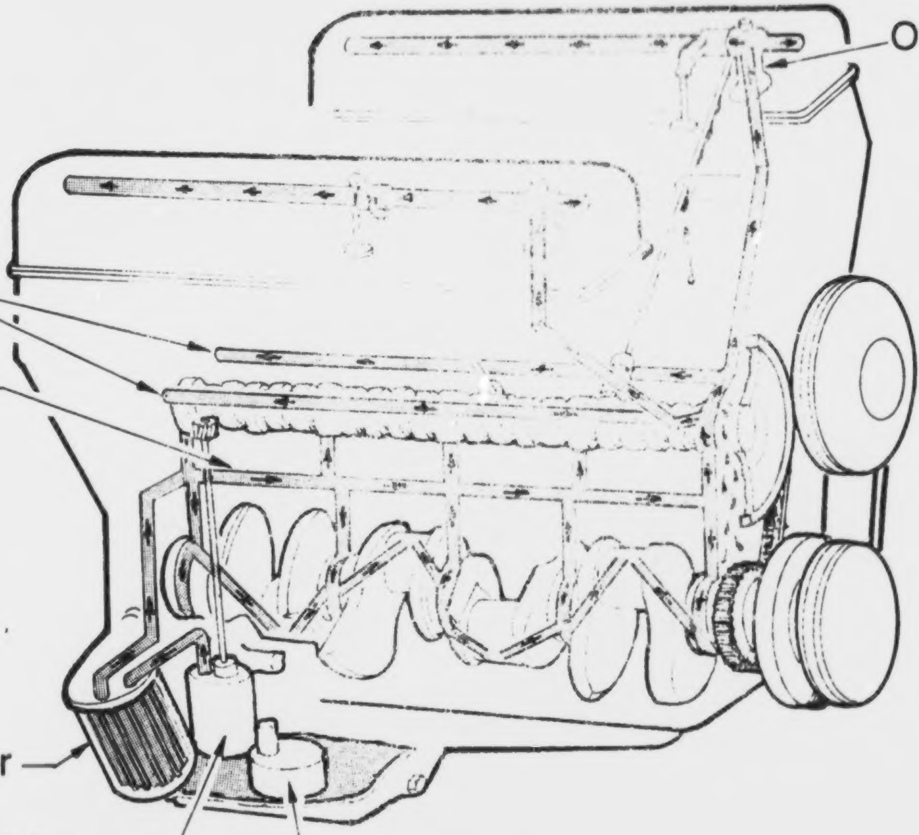
201

Remove cover
to check oil level



202

The Engine Lubrication System



Oversized Bolt Hole

Valve Lifter Oil Galleries

Main Oil Gallery

Oil Filter

Oil Pump

Pickup

TM-12

II-6-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Lubrication Systems

TOPIC: Lubrication

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the lubrication system.

2. Match the terms on the right to the correct definition associated with the lubrication system.

_____a. Resistance to any motion between two surfaces in contact

_____b. A by-product of petroleum used for lubrication

_____c. A device used to prevent oil leakage past a certain point in the engine

_____d. A part of the lubrication system used to clean the oil

_____e. A device used to force oil through the engine

_____f. Unit using oil to clean air entering the engine

_____g. Any material used to prevent friction between two surfaces

1. Oil
2. S.A.E.
3. Sump
4. Friction
5. Additive
6. Oil seal
7. Oil pump
8. Differential

_____h. A unit that drives both rear axles, but will allow them to turn at different speeds when making turns

_____i. A material or solution added to a mixture to increase efficiency

_____j. A metal stick used to measure the oil level in an engine or automatic transmission

_____k. Society of Automotive Engineers

_____l. Motor severe oil

_____m. The part of the engine that holds the oil

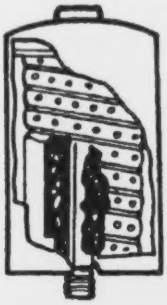
9. Lubricant
10. MS
11. Dipstick
12. Oil Filter
13. Oil bath cleaner

3. Point out the five functions of oil by underlining the letter in front of each correct answer.

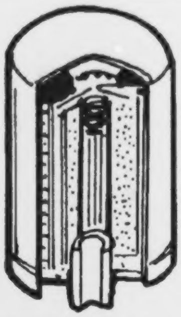
a. Cools
b. Softens
c. Cleans
d. Glues
e. Cushions
f. Lubricates
g. Seals

4. Select the proper type of oil filter by writing the correct name for each of the following filters.

a.____________________



b.____________________



5. Pick out the types of lubrication systems from the following list by underlining each correct answer.

a. Slow-drip oiling
b. Full-pressure oiling
c. Splash oiling
d. Combination slow-drip and splash oiling
e. Combination full-pressure and splash oiling

6. Point out the factors that cause lubricants to break down by writing **yes** or **no** in front of each of the following.

_____a. Moisture

_____b. Freezing

_____c. Sunlight

_____d. Excessive heat

_____e. Dirt

_____f. Misuse

_____g. High engine RPM

7. Choose from the list at right the correct type of lubricant used in each of the vehicle areas listed at left.

_____a. For use in the engine

_____b. Used on ball joints, wheel bearings, and u-joints

_____c. For use in manual transmissions

_____d. For use in automatic transmissions

1. Grease
2. Gear oil
3. Motor oil
4. ATF lubricant

II-6-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Lubrication System

TOPIC: Check Engine Oil Level

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check the engine oil level.

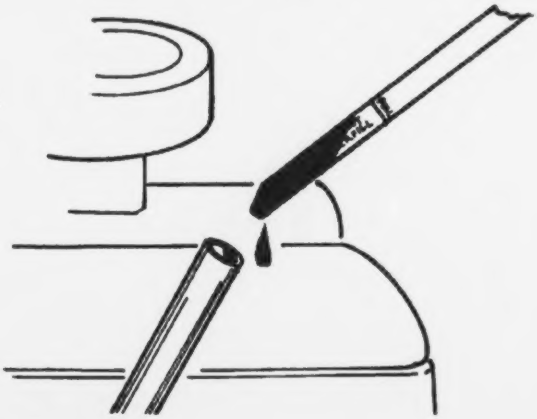
TOOLS AND EQUIPMENT:
Shop towel
Oil, if needed
Oil spout

GENERAL INSTRUCTIONS: Follow procedures to check engine oil level properly.

PROCEDURES AND/OR TASKS **Note:** *Follow all safety rules.*

1. Park car on level ground and allow to sit for a few minutes with the motor **off**.
2. Raise hood.
3. Locate dipstick.
4. Remove dipstick.
5. Wipe off dipstick with shop towel.
6. Put dipstick back into dipstick tube and push down as far as possible.
7. Remove dipstick.

8. Read the oil level on the dipstick markings.



9. Put dipstick back into dipstick tube.

10. Add the correct amount of oil that the dipstick indicates the crankcase needs.

11. If oil is added, recheck the oil level.

12. Have instructor check work.

13. Close car hood.

14. Replace tools and equipment.

15. Clean the work area.

II-6-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Lubrication System

TOPIC: Change Engine Oil

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to change engine oil.

TOOLS AND EQUIPMENT:

- Shop towel
- Proper size wrench
- Drain pan
- Auto manual
- Oil spout
- Hydraulic floor jack
- Two jack stands
- Fender cover

GENERAL INSTRUCTIONS: Follow procedures to change engine oil properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow all safety rules.*

1. Raise the car enough to place jack stands.
   Note: *Use hydraulic lift if available.*
2. Place jack stands under frame of car.
3. Place the drain pan under the drain plug.
4. Remove oil pan drain plug.
   CAUTION: Oil may be hot.
5. Let oil drain completely.

6. Install oil pan drain plug
   CAUTION: Tighten the plug securely but be careful not to strip the threads.
7. Raise car and remove jack stands and let down slowly.
8. Raise hood and put on fender cover.
9. Go to Job Sheet #3 if the engine oil filter needs to be replaced.
10. If the filter is not to be replaced, remove the oil filler cap.
11. Put in correct amount of oil.
12. Install oil filler cap.
13. Check the engine oil level.
14. Add oil, if necessary.
15. Have instructor check work. After this, start the engine and check for leaks. If there are no leaks from the drain plug or filter, the job is finished.
16. Close the car hood.
17. Replace tools and equipment.
18. Dispose of used oil.
19. Clean the work area.

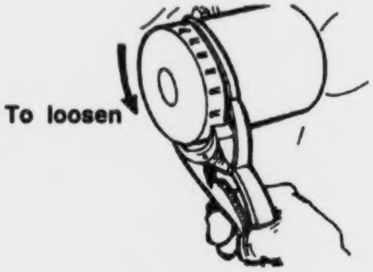
JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

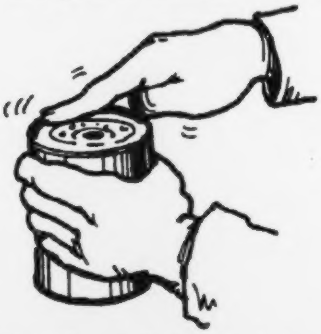
NAME ______________________________ **DATE** ________________

UNIT:	Lubrication System
TOPIC:	Change Engine Oil Filter (Screw-on Type)
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to change engine oil filter.
TOOLS AND EQUIPMENT:	Shop towel Oil filter wrench New oil filter Drain pan Fender cover
GENERAL INSTRUCTIONS:	Follow procedures to change engine oil filter properly.
PROCEDURES AND/OR TASKS	**Note:** *Follow all safety rules.*

1. Open car hood and put on fender cover.
2. Put drain pan under oil filter area.
3. Remove the oil filter with the oil filter wrench by turning the filter counterclockwise.



4. Rub oil on the surface of the gasket on the new filter.



5. Run the filter up on the threads until the gasket touches the base.
   Note: *Clean the base, before installing a filter.*

6. Turn the filter one-half of a turn more.

7. Follow Job Sheet #2 instructions for oil filling.

8. After engine has been filled to the proper oil level, place transmission in neutral and set parking brake.

9. Start engine and allow it to warm up.

10. Switch off engine.

11. Check for oil leaks around filter and drain plug.

12. Check oil level on dipstick and add oil if necessary.

13. Have instructor check work.

14. Close hood.

15. Replace tools and equipment.

16. Clean the work area.

II-6-JS-4

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Lubrication System

TOPIC: Check Automatic Transmission Fluid Level

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check automatic transmission fluid level.

TOOLS AND EQUIPMENT:

Shop towel
Transmission fluid
Funnel
Fender cover

GENERAL INSTRUCTIONS: Follow procedures to check automatic transmission fluid level properly.

PROCEDURES AND/OR TASKS: Check operator manual.
Note: *Follow all safety rules.*

1. Place transmission in park and secure parking brake.
2. Start the engine and allow it to warm to normal operating temperature.
3. Switch off the engine.
4. Raise the car hood and put on the fender cover.
5. Locate the transmission dipstick and remove.
6. Wipe off the dipstick with a rag.

7. Put the dipstick back into the tube and push in as far as possible.

8. Remove the dipstick and read the fluid level on the dipstick markings.

9. Add fluid in the dipstick tube if the fluid reading on the dipstick shows to be low. **Note:** *At least one pint is required if the oil level is on add.*

10. Replace dipstick.

11. Have instructor check work.

12. Close hood.

13. Replace tools and equipment.

14. Clean the work area.

II-6-JS-5

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Lubrication System

TOPIC: Change Automatic Transmission Fluid

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to change automobile transmission fluid.

TOOLS AND EQUIPMENT:

Shop towel
Proper size wrench to remove drain plug
Drain pan
Transmission fluid as required
Filter and gasket kit
Funnel
Hydraulic floor jack
Fender cover
Two jack stands

GENERAL INSTRUCTIONS: Follow procedures to change automatic transmission fluid properly.

PROCEDURES AND/OR TASKS Note: *Follow all safety rules.*

1. Place transmission in park and secure parking brake.
2. Raise car to necessary height.
   Note: *Use hydraulic lift if available.*
3. Place jack stands under frame of vehicle.
4. Place drain pan in proper location.
   WARNING: If the engine is warm, the transmission fluid will be hot.

5. If the transmission oil pan has a drain plug, remove it. Otherwise, begin removing the pan bolts. Do not fully remove the last 2 bolts. The pan will pull away from the transmission, allowing the fluid to spill out. Be sure your drain pan is in place.

6. Remove the transmission oil pan and allow transmission to drain completely.

7. Clean the oil pan thoroughly and scrape all gasket residue off of the rails.

8. Under the car, remove the transmission filter. Install the new filter, using any seals or gaskets provided.

9. Wipe off the pan mounting surface on the transmission. Be sure the surface is clean and smooth.

10. Install drain plug or oil pan. Be sure gasket lays flat, tighten the pan bolts evenly using a torque wrench set to 12 ft/lbs.

11. Remove jack stands and lower slowly to floor.

12. Raise hood and put fender cover in place.

13. Remove dipstick and add new fluid.
    Note: *Add only about half as much fluid as was drained.*

14. Start the engine and add fluid necessary to bring the fluid level to the full mark on the dipstick. With the brakes firmly applied, shift the car slowly through the gear ranges several times. Put the transmission in park and recheck the oil level.

15. Check fluid level and check for leaks.

16. Switch off engine.

17. Have instructor check work.

18. Close hood.

19. Replace tools and equipment.

20. Clean the work area.

II-6-JS-6

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ DATE ______________

UNIT: Lubrication System

TOPIC: Check Standard Transmission Oil Level

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

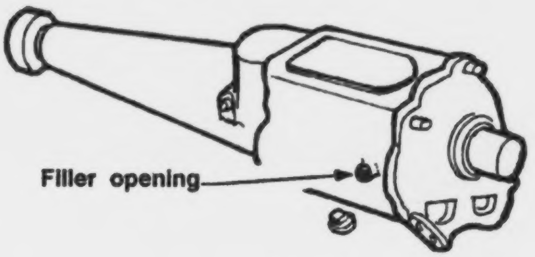
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check standard transmission oil level.

TOOLS AND EQUIPMENT:
Shop towel
Transmission oil
Wrench to fit transmission plug
Hydraulic floor jack
Two jack stands

GENERAL INSTRUCTIONS: Follow procedures to check a standard transmission oil level.

PROCEDURES AND/OR TASKS: Check operator manual.
Note: *Follow all safety rules.*

1. Raise car enough to place jack stands.
2. Place jack stands under frame of car.
3. Locate filler plug on transmission and remove.



4. Place transmission filler spout in filler opening.
5. Add transmission oil until it runs out the filler hole.
6. Wait until gear oil no longer runs out, then install the filler plug and tighten securely.
7. Remove jack stands and lower the car to the floor.
8. Have instructor check work.
9. Replace tools and equipment.
10. Clean the work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Lubrication System

TOPIC: Check Differential Oil Level

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check differential oil level.

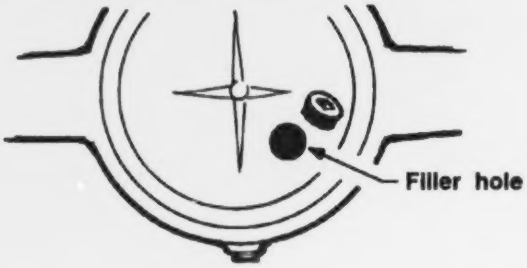
TOOLS AND EQUIPMENT:

Shop towel
Transmission oil
Wrench to fit differential plug
Hydraulic floor jack
Two jack stands

GENERAL INSTRUCTIONS: Follow procedures to check the differential oil level properly.

PROCEDURES AND/OR TASKS: Check operator manual.
Note: *Follow all safety rules.*

1. Raise car high enough to place jack stands.
2. Place jack stands under frame of car.
3. Locate the differential filler plug and remove.



4. Insert the filler spout in the filler hole.
5. Add oil until it runs out the filler hole.
6. When gear oil no longer runs out, install the filler plug and tighten securely.
7. Remove jack stands and lower the car to the floor.
8. Have instructor check work.
9. Replace tools and equipment.
10. Clean the work area.

JOB SHEET

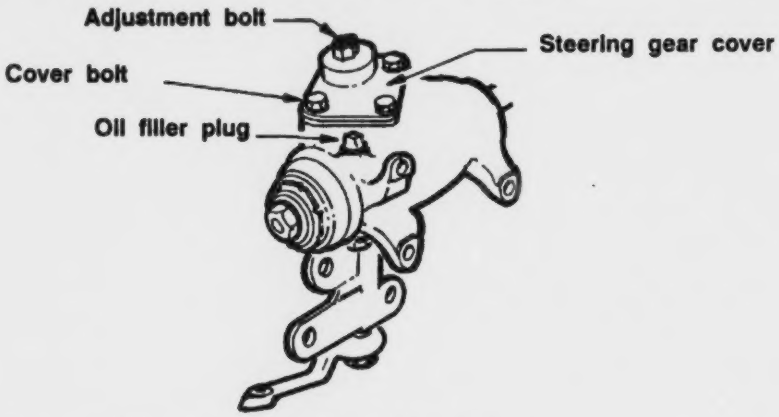
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ DATE ______________

UNIT:	Lubrication System	
TOPIC:	Check Manual Steering Gear Oil Level	
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)	
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to check the manual steering gear oil level.	
TOOLS AND EQUIPMENT:	Shop towel Wrench to fit manual steering plug	Fender cover Gear oil
GENERAL INSTRUCTIONS:	Follow procedures to check the manual steering gear oil level properly.	
PROCEDURES AND/OR TASKS	Check operator manual. **Note:** *Follow all safety rules.*	

1. Raise hood and put on fender cover.
2. Locate oil filler plug on steering gearbox.
   Note: *Do not mistake the steering gear adjustment nut and screw for the filler plug.*

3. Remove the plug.
   Note: *A cover bolt must be removed on some steering gearboxes to check the oil level.*


Adjustment bolt
Steering gear cover
Cover bolt
Oil filler plug

4. Add oil until it can be seen through the filler hole.

5. Install the plug.

6. Have instructor check work.

7. Close hood.

8. Replace tools and equipment.

9. Clean the work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** __________________

UNIT: Lubrication System

TOPIC: Check Power Steering Pump Oil Level

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

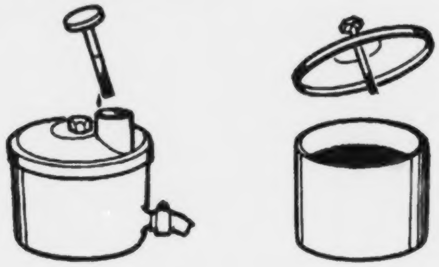
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to check the power steering pump oil level.

TOOLS AND EQUIPMENT:
Shop towel
Power steering oil
Fender cover

GENERAL INSTRUCTIONS: Follow procedures to check the power steering pump oil level properly.

PROCEDURES AND/OR TASKS Check operator manual.
Note: *Follow all safety rules.*

1. Raise hood and put on fender cover.
2. Clean the top of the pump around the dipstick.
3. Remove the dipstick and wipe clean.



Note: *Some models have a cover that must be removed.*

4. Push the dipstick back into the power steering pump.
5. Remove the dipstick and read the oil level on the dipstick markings.
6. Add oil through the dipstick tube if necessary.
7. Have instructor check work.
8. Close hood.
9. Replace tools and equipment.
10. Clean the work area.

II-6-JS-10

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE __________________

UNIT: Lubrication System

TOPIC: Lubricate Chassis

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lubricate the chassis.

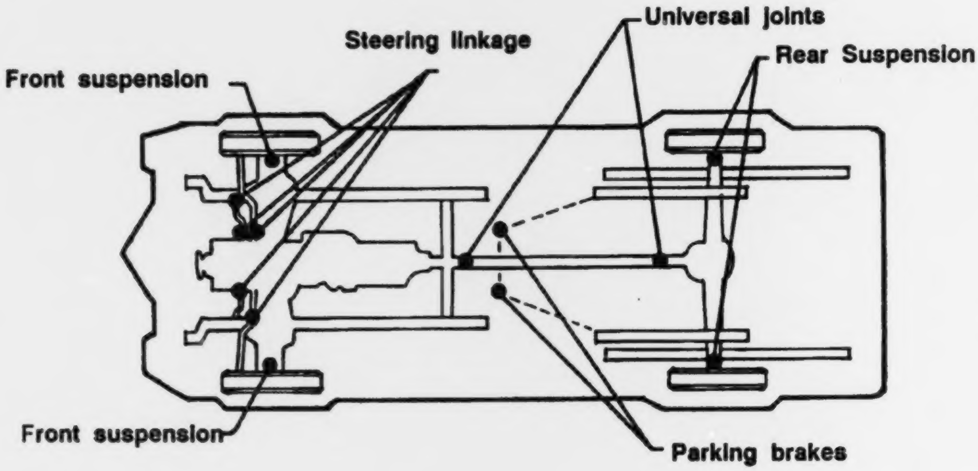
TOOLS AND EQUIPMENT:
Shop towel
Grease gun and appropriate grease
Auto service manual
Hydraulic floor jack
Two jack stands

GENERAL INSTRUCTIONS: Follow procedures to lubricate the chassis properly.

PROCEDURES AND/OR TASKS
Check operator manual
Note: *Follow all safety rules.*

1. Raise car high enough to place the jack stands.
2. Place jack stands under the frame of the car.

3. Refer to the auto service owner's manual for locating the car's lubrication points.


Universal joints
Steering linkage
Rear Suspension
Front suspension
Front suspension
Parking brakes

4. If plugs are in the lube points, remove plugs and install grease fittings.

5. Wipe grease fittings clean.

6. Push grease gun nozzle onto fitting.

7. Pump grease gun until grease squeezes out around the edges of the unit being greased.

8. Grease all fittings on the car.

9. Check all gear boxes for the proper oil level.
   Example: *Differential, steering, transmission, etc.*

10. Have instructor check work.

11. Remove jack stands and lower car to the floor.

12. Replace tools and equipment.

13. Clean the work area.

STUDENT INFORMATION SHEET

MINOR AUTOMOTIVE MAINTENANCE

UNIT:	Engine Cooling System
TOPIC:	Cooling Systems
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to inspect, test, and service the parts within the cooling system.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to test, check and replace parts of the cooling system.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with the engine cooling system include science, mathematical principles, reading concepts, and oral and written communications.*

Engine Cooling Systems

The purpose of automotive engine cooling is to control the metal temperatures within safe limits by removing the excess heat produced by the engine.

In the **cooling system** the heat is transferred by the coolant. The flow of coolant will continually carry a load of heat from the engine water jacket into the radiator for transfer to the outside air. The fan draws air through the radiator, cooling the metal and coolant. The coolant then returns to the engine to absorb more heat.

The **water pump** circulates the coolant to provide adequate cooling. The pump draws the coolant from the radiator, then circulates it through the passages around the cylinders and combustion chambers to absorb the heat.

The functions of the cooling system are as follows:

- Brings coolant and engine up to operating temperature quickly.
- Keeps the coolant and engine at an even temperature.
- Removes unwanted heat by circulating the coolant.

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Terms and Definitions

Antifreeze is a liquid made of ethylene glycol that prevents the coolant from freezing and aids in overheating problems.

Belt is a flexible rubber and steel strap used to drive the water pump from the crankshaft by pulleys.

Fan is a unit located to the rear of the radiator that pulls air through the radiator and is driven by belts from the crankshaft.

Fan clutch is a device mounted on the fan hub that allows the fan to cut out at speeds over 50 mph to give extra power to the engine at high speeds.

Hoses connect the radiator to the engine and water pump.

Radiator is a square unit filled with coolant, located in front of the engine, from which heat generated in the engine leaves the system.

Radiator cap seals the radiator and allows the system to operate under pressure.

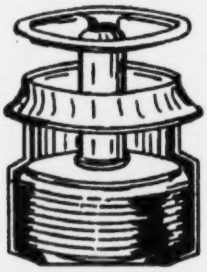
Thermostat is a unit, located in the engine head outlet, that controls engine coolant temperature.

Water pump is a unit designed to move coolant through the cooling system.

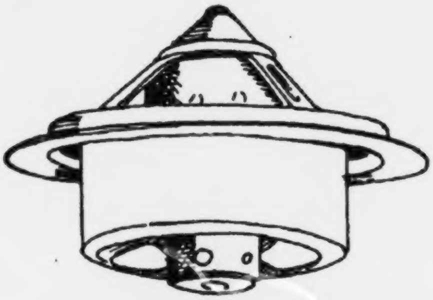
Types of Thermostats

The thermostat is installed in the engine water outlet to maintain a safe operating temperature in the engine. The thermostat is designed for continuous use in winter and summer. The most common thermostat used today is the poppet valve thermostat. When heat is applied, the valve element will move downward away from the valve seat, against the compression spring. At a preset temperature the control will start to open the valve and regulate the amount of coolant flow throughout the system. As the system cools, the valve will start to close.

The **bellows** is a low-pressure thermostat which contains a liquid that creates pressure upon evaporation, causing the valve to open.



The **pellet** is a high-pressure thermostat which uses a wax pellet that expands with temperature, causing the valve to open.



Antifreeze/Coolant

The antifreeze/coolant is added to the water in the cooling system to keep the system from boiling or freezing. The coolant contains a chemical called **ethylene glycol**, which will keep water from freezing at temperatures below 32 degrees F.

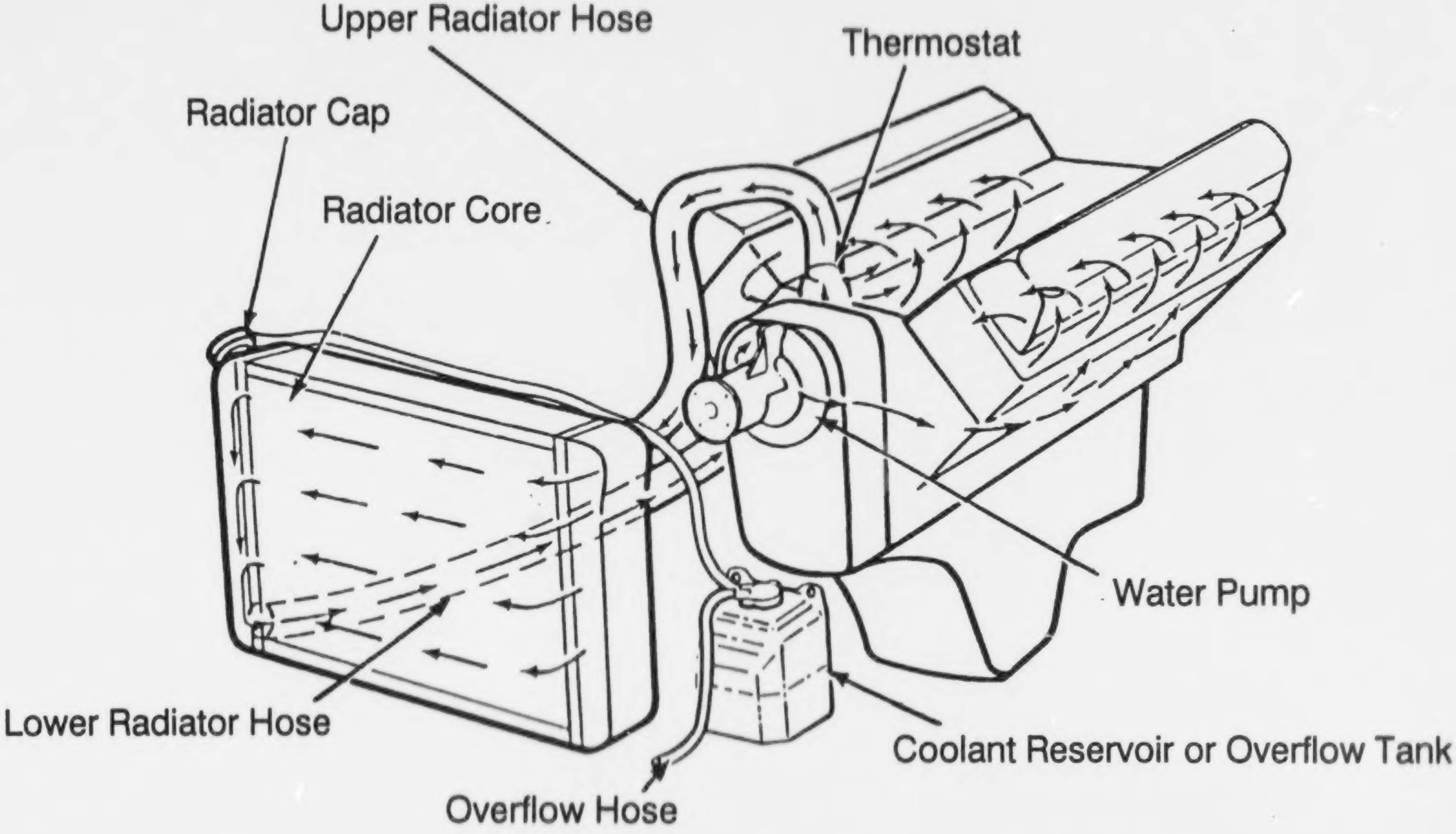
The antifreeze/coolant will not boil until heated in excess of 212 degrees F.

Coolant contains approximately 95 percent ethylene glycol plus rust, corrosion and foaming inhibitors. This helps to prevent rust on metal surfaces and lubricates the water pump.

Some of the characteristics of coolant are:

- The freezing point is much lower than water. If water is to be added, use distilled water because of its lower mineral content.
- The ethylene glycol helps to prevent boil over during hot weather.
- The coolant is poisonous if swallowed
  Note: *Seek medical help immediately.*
- The useful life of antifreeze is approximately 24 months.
- Antifreeze will remove or damage paint on car bodies and should be cleaned up immediately if spilled.

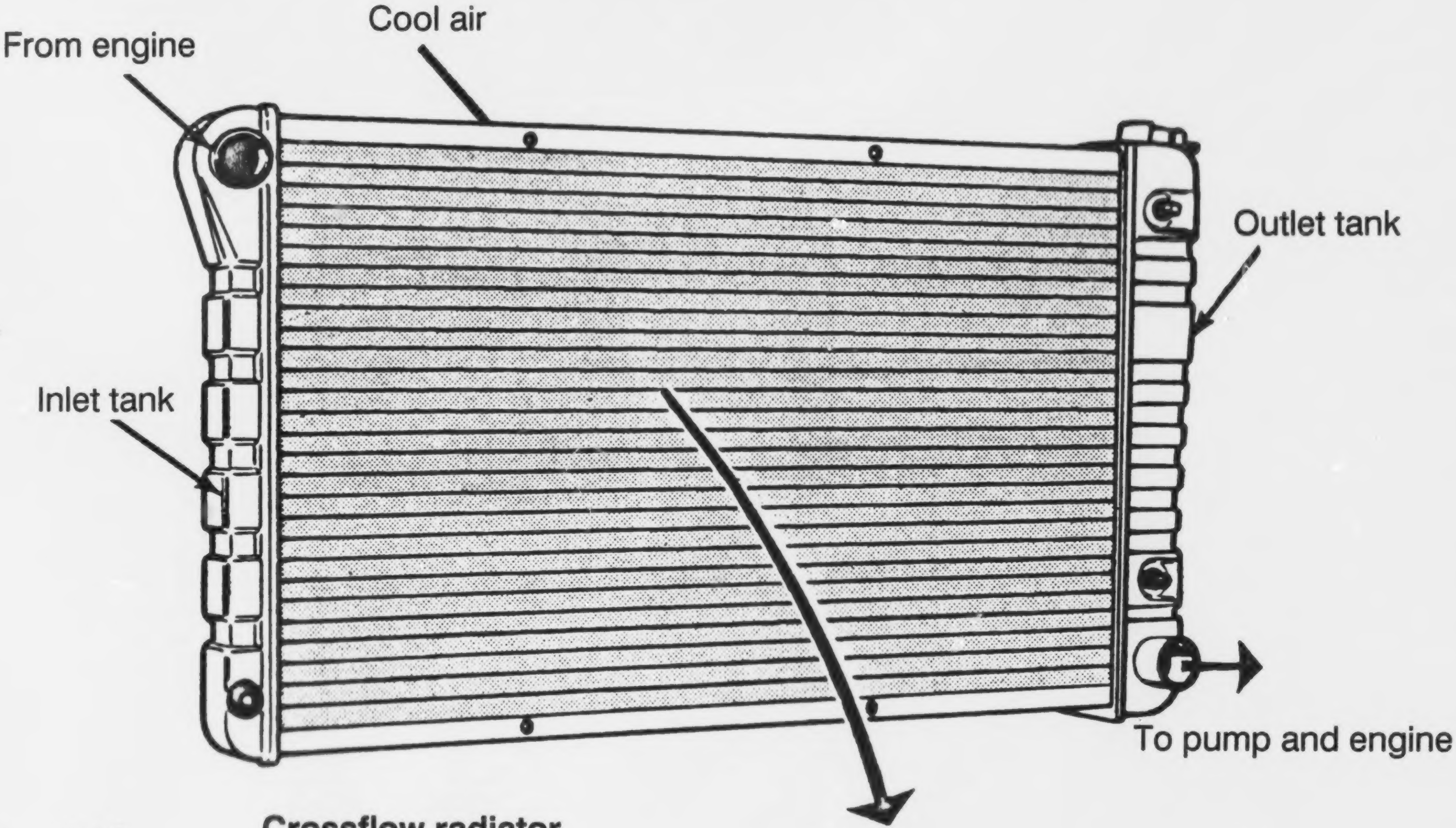
The Cooling System


Upper Radiator Hose
Thermostat
Radiator Cap
Radiator Core
Water Pump
Lower Radiator Hose
Coolant Reservoir or Overflow Tank
Overflow Hose

Coolant flow path in a system employing a cross-flow radiator.
This is a closed system. Note use of overflow tank.

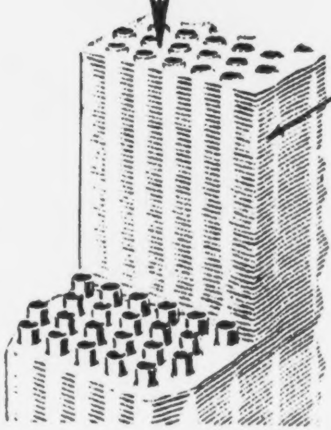
TM-1

The Radiator


Cool air
From engine
Outlet tank
Inlet tank
To pump and engine

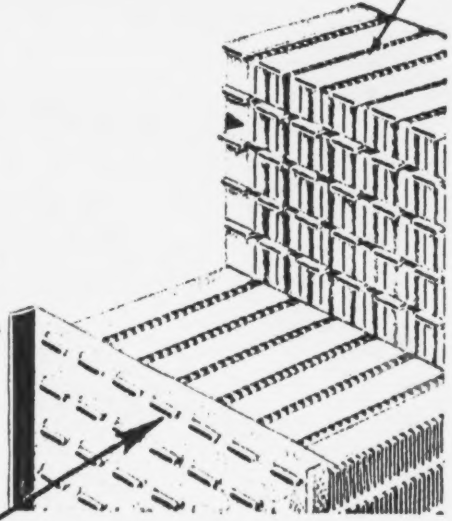
Crossflow radiator

Radiator Tubes and Fins



Coolant flow

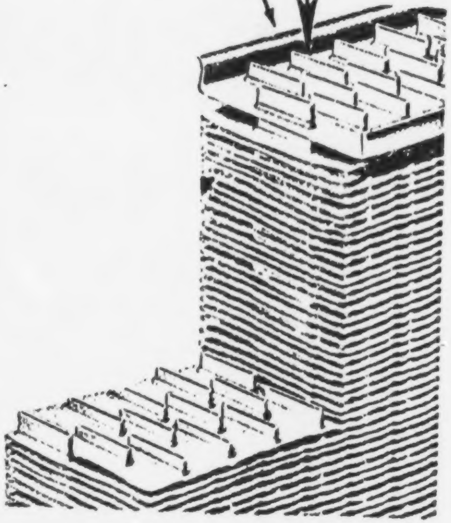
Round tube and fin construction



Flat tube and corrugated fin construction

Tank

Coolant flow

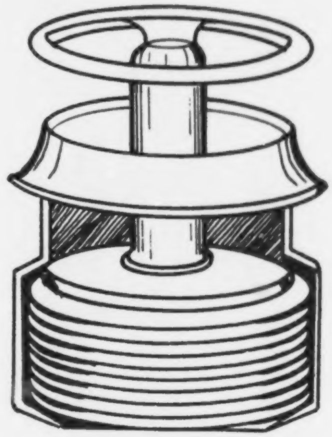


Coolant flow

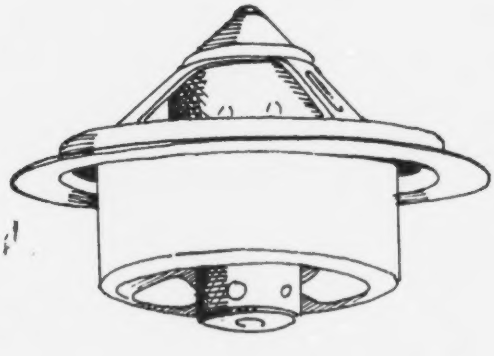
Tank

Flat tube and fin construction

Types of Thermostats

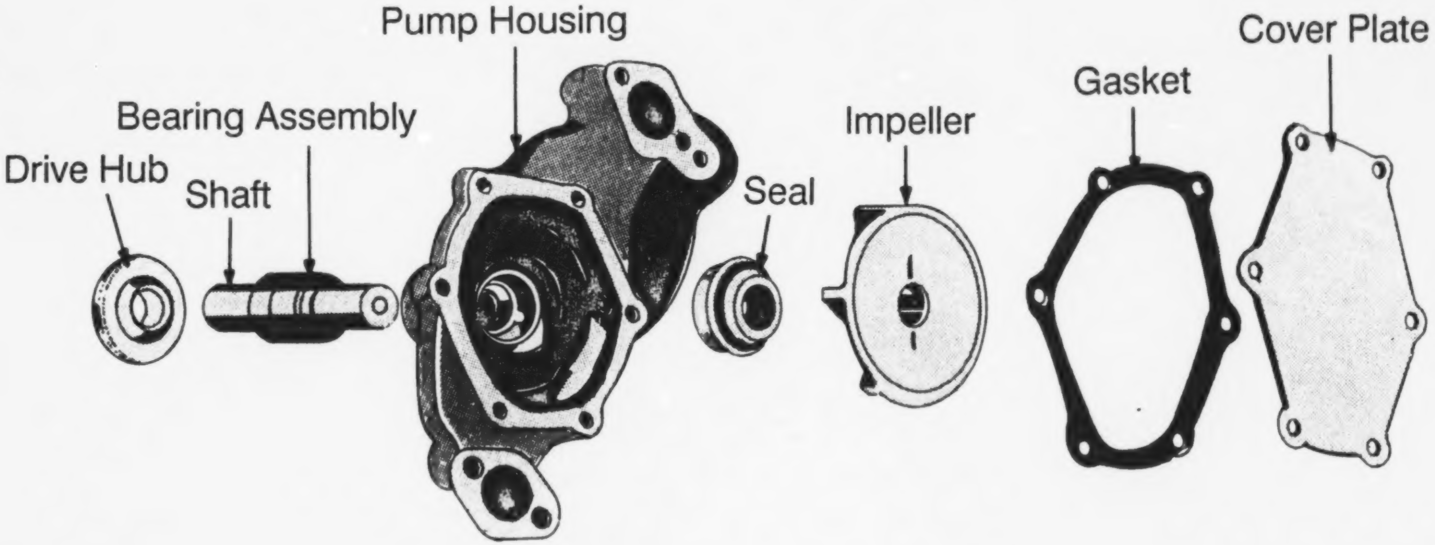


Bellows

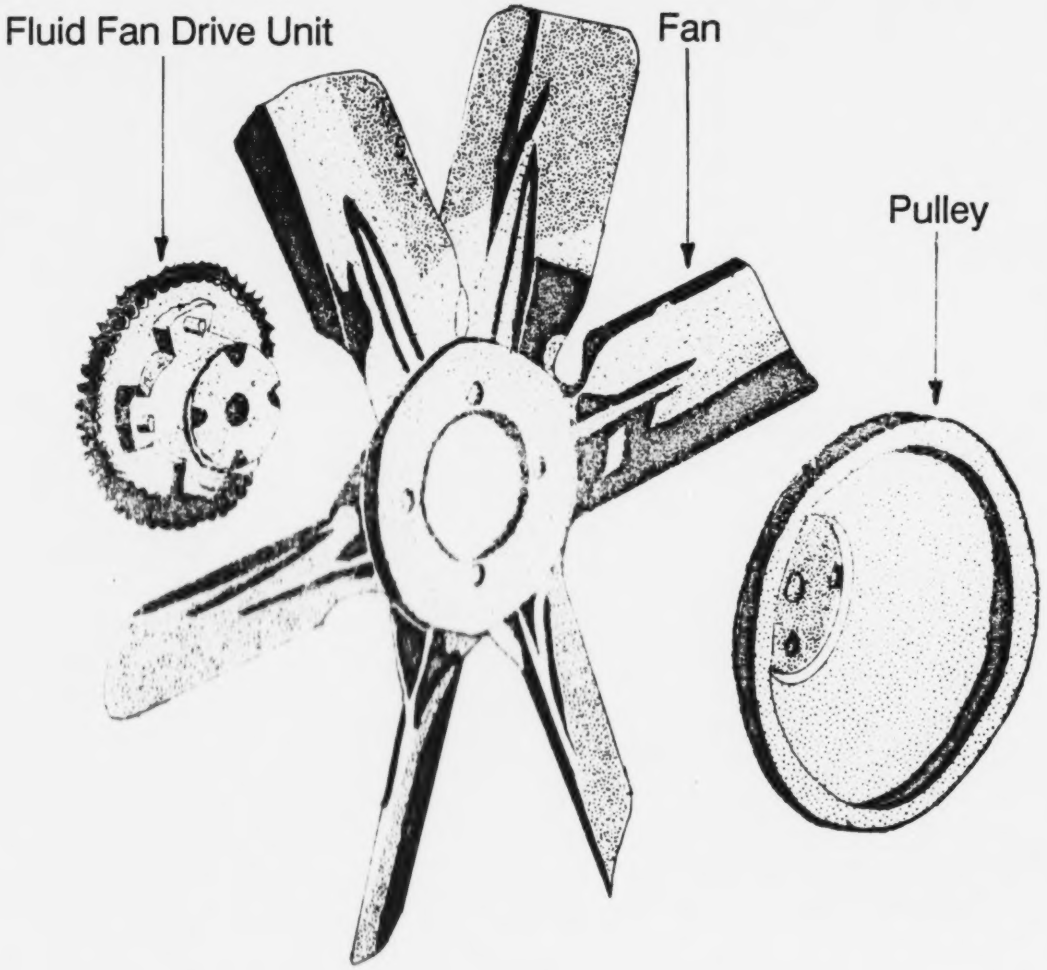


Pellet

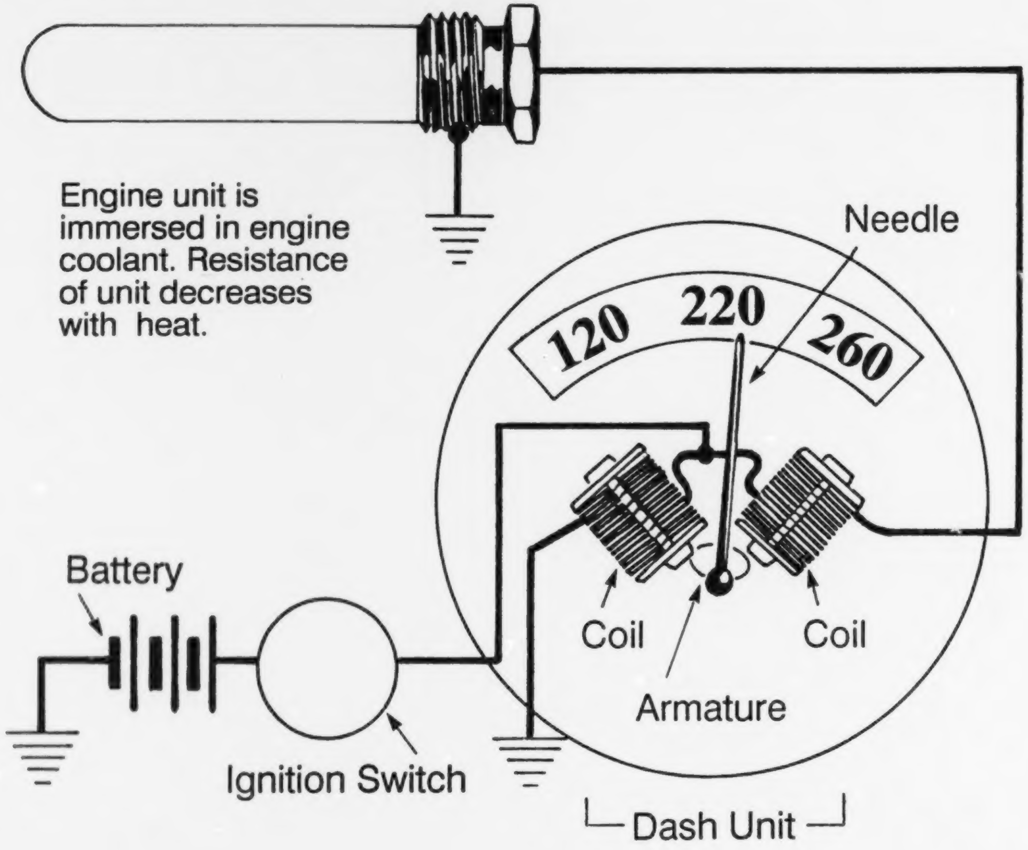
The Water Pump


Pump Housing
Cover Plate
Gasket
Bearing Assembly
Impeller
Drive Hub
Shaft
Seal

The Fan


Fluid Fan Drive Unit
Fan
Pulley

The Temperature Indicator System



Engine unit is immersed in engine coolant. Resistance of unit decreases with heat.

Needle
120
220
260
Battery
Coil
Coil
Armature
Ignition Switch
Dash Unit

ASSIGNMENT SHEET
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Engine Cooling System

TOPIC: Cooling Systems

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the cooling system.

2. Point out the three functions of the cooling system by answering **yes** or **no** to each of the following statements.

_____a. Brings coolant and engine up to operating temperature quickly

_____b. Stores heat to fire the fuel-air mixture in the cylinders

_____c. Keeps coolant and engine at an even temperature

_____d. Cools exhaust system

_____e. Removes unwanted heat

3. Match the terms with the definitions associated with the cooling system.

_____a. A square unit located in front of the engine, filled with coolant, from which heat generated in the engine leaves the system

_____b. A unit designed to move coolant through the cooling system

1. Belt
2. Fan
3. Water pump
4. Fan clutch

_____c. A unit located in the engine head outlet that controls engine coolant temperature

_____d. Connects radiator to the engine and water pump

_____e. Seals the radiator and allows the system to operate under pressure

_____f. A liquid made of ethylene glycol that prevents the coolant from freezing, and aids in overheating problems

_____g. A unit located to the rear of the radiator that pulls air through the radiator and is driven by belts from the crankshaft

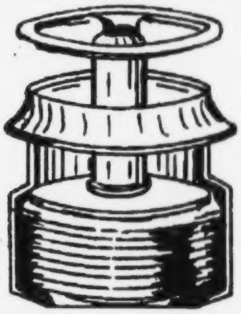
_____h. A device mounted on the fan hub that allows the fan to cut out at speeds over 50 mph

_____i. A flexible rubber and steel strap used to drive the water pump from the crankshaft by pulleys

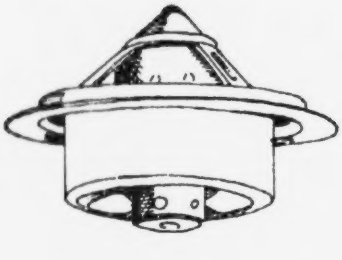
5. Antifreeze
6. Radiator
7. Hoses
8. Thermostat
9. Radiator cap

4. Select the correct type of thermostat by labeling each of the illustrations with either **bellows** or **pellet**.

a.________________________



b.______________________



5. Point out the types and uses of antifreeze by underlining the correct answer for each of the following questions:

   a. The two types of antifreeze are (permanent, replaceable) ethylene glycol and (permanent, replaceable) alcohol antifreeze.
   b. Antifreeze has a much (higher, lower) freezing point than water.
   c. The (ethylene glycol, alcohol) type prevents boil over during hot weather.
   d. It is (poisonous, non-poisonous) if swallowed.

e. The useful life of most antifreeze is (24 months, 24 years).
f. It (will, will not) remove paint from car bodies.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

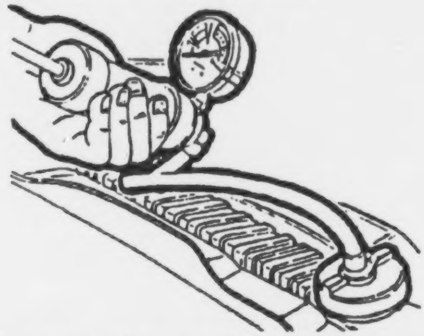
UNIT:	Engine Cooling System
TOPIC:	Pressure Check Radiator
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to pressure check the radiator.
TOOLS AND EQUIPMENT:	Cooling system pressure tester Auto service manual Fender cover Face shield
GENERAL INSTRUCTIONS:	Follow procedures to pressure check the radiator properly.
PROCEDURES AND/OR TASKS:	Check service/operator manual. **Note:** *Follow all safety rules.*

1. Place the transmission in neutral/park and set the parking brake.

2. Raise the hood and put on the fender cover.

3. Remove the radiator cap.
   CAUTION: **If the engine is hot, allow it to cool before removing the radiator cap.**

4. Attach the cooling system tester to the radiator.



5. Look in the auto service manual or on the radiator cap of the system being tested to find the correct pressure required.

6. If pressure is low and hoses are okay, check on internal problems.

7. Build up pressure in the system to the amount specified in the auto service manual or on the cap.

8. After the pressure is built up to the correct amount, watch the gauge for changes.
Note: *The system should hold steady pressure for 2 minutes.*

9. If the pressure drops, check all areas for leaks.

10. If no leaks are visible, check the connection of the pressure tester to the radiator at the filler neck.

11. Start the engine and allow to warm up to operating temperature with heater on maximum.
Note: *Some systems show leaks only when warm.*

12. Turn off engine and pressurize the radiator.

13. When pressure test is completed, return the coolant level to top of the radiator and overflow bottle (refer to owner's manual).

14. Replace the radiator cap.

15. Have instructor check work.

16. Close the car hood.

17. Replace tools and equipment.

18. Clean the work area.

II-7-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ **DATE** ____________________

UNIT:	Engine Cooling System	
TOPIC:	Pressure Check Radiator Cap	
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)	
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to check the pressure on the radiator cap.	
TOOLS AND EQUIPMENT:	Cooling system pressure tester New radiator cap	Fender cover Face shield
GENERAL INSTRUCTIONS:	Follow procedures to check the pressure for the radiator cap properly.	
PROCEDURES AND/OR TASKS:	Check service/operator manual. **Note:** *Follow all safety rules.*	

1. Raise hood and put on the fender cover.

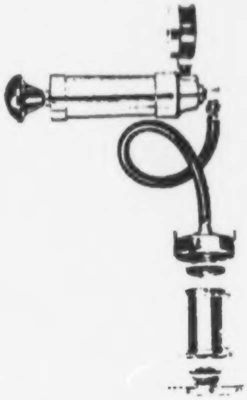
2. Remove radiator cap.

3. Read the pressure limits on the cap.

4. Check the rubber seal for cracks at the base of the cap.

5. Install the cap on the tester adapter.

6. Pump the pressure to the limit shown on the cap.



7. Watch the tester gauge.

8. If pressure gauge goes rapidly, wet the rubber surfaces on the cap and adapter and recheck.
   Note: *If the pressure holds, the cap is good.*

9. If the pressure goes down again, check the new cap against the old one. (If the new cap will hold pressure, the old one is bad and should be replaced.)

10. Install a good cap on the radiator.

11. Have instructor check work.

12. Close the hood.

13. Replace tools and equipment.

14. Clean the work area.

II-7-JS-3

JOB SHEET

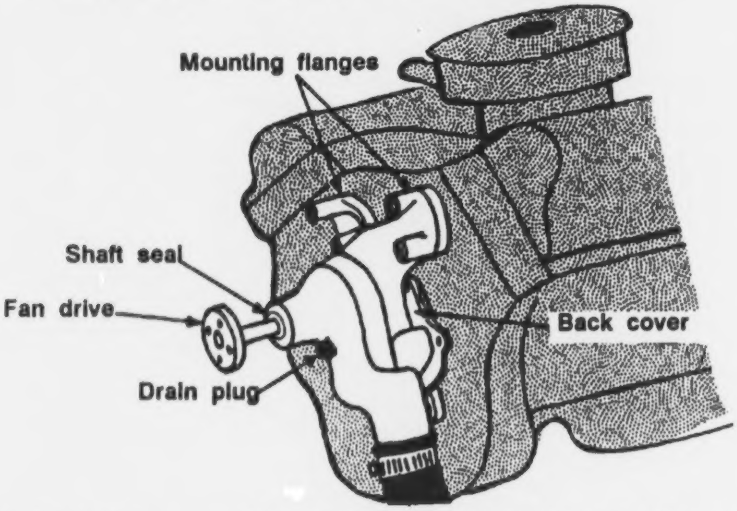
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** __________________

UNIT:	Engine Cooling System
TOPIC:	Inspect Water Pump
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to inspect the water pump properly.
TOOLS AND EQUIPMENT:	Drive socket set Fender cover
GENERAL INSTRUCTIONS:	Follow procedures to inspect the water pump properly.
PROCEDURES AND/OR TASKS:	Check service/operator manual. **Note:** *Follow all safety rules.*

1. Place transmission in neutral/park and set parking brake.
2. Raise the car hood and put on the fender cover.
3. Check for worn water pump bearings and loose fan blades by working the fan blades back and forth.
   Note: *Excess slack in the shaft would indicate bad water pump bearings.*

4. Look for leaks around the pump-mounting flanges.


Mounting flanges
Shaft seal
Fan drive
Back cover
Drain plug

5. Check the water pump shaft drain seal hole for leakage (located at the bottom of the pump).

6. If no leaks are found, tighten fan belts.

7. If leaks are found, the pump should be changed or taken off and leaks repaired.

8. Have instructor check work.

9. Close the car hood.

10. Replace tools and equipment.

11. Clean the work area.

II-7-JS-4

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Engine Cooling System

TOPIC: Remove and Replace Thermostat

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the thermostat.

TOOLS AND EQUIPMENT:

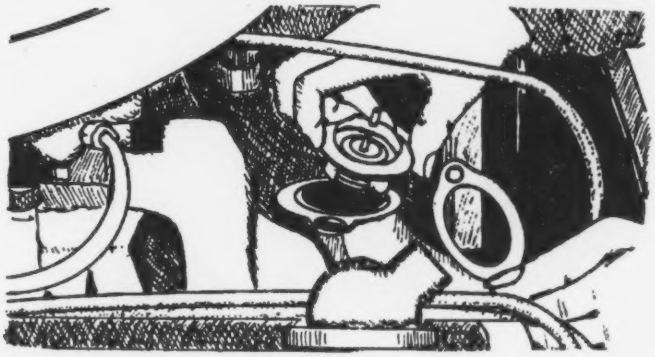
Drive socket set
Hose clamp pliers
Common screwdriver
Gasket Scraper
Drain container
Fender cover
Gasket sealant

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the thermostat properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Place transmission in neutral/park and set parking brake.
2. Raise the car hood and put on the fender cover.
3. Remove the radiator cap.
   CAUTION: If the engine is hot, allow it to cool before removing cap.
4. Place the drain container under the radiator drain cock and drain the coolant to below the top neck of the radiator.
5. Remove the top radiator hose at the engine, using a common screwdriver or hose clamp pliers.

6. Remove the thermostat housing bolts and housing.
7. Remove the thermostat.
8. Scrape the old gasket or O ring from the thermostat housing and engine surface, using a scraper.
9. Wipe any moisture from the housing and engine surface.
10. Install the new gasket or O ring on the surface of the engine.
11. Place a good thermostat in the engine-mount slot, with the pellet side down.



12. Install the thermostat housing and bolts.
13. Tighten securely with socket set.
14. Install top radiator hose to thermostat housing and tighten with a common screwdriver or hose clamp pliers.
15. Close the drain cock on the bottom of the radiator.
16. Refill the radiator to manufacturer's specifications.
17. Install the radiator cap.
18. Check the hose and housing for leaks.
19. Have instructor check work.
20. Close the hood.
21. Replace tools and equipment.
22. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Engine Cooling System

TOPIC: Test Thermostat for Operation

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to test the thermostat for operation.

TOOLS AND EQUIPMENT:

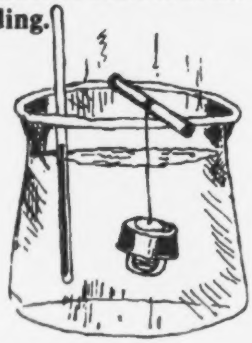
A metal container filled with water
Oxyacetylene welding unit,
hot plate or other heating source
Thermometer
A wire hook

GENERAL INSTRUCTIONS: Follow procedures to test the thermostat for operation properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Hang the thermostat from the wire hook, with the pellet side down, in the container of water.
   CAUTION: **Do not let the thermometer touch the sides or bottom of the container. This would cause an improper reading.**

2. Heat the bottom of the container.



3. Gently stir the water as the heat rises on the thermometer.
4. Watch the thermostat for opening as the temperature rises.
   Note: *The thermostat should open within 10 degrees of that marked on its base.*
5. Continue heating until the thermostat is fully open.
6. Check the thermometer for the temperature at which the thermostat fully opens.
   Note: *It should be 2O to 24 degrees above the temperature marked on the thermostat.*
7. Discard the thermostat if it does not work properly.
   Note: *Do not attempt to repair the thermostat.*
8. Have instructor check work.
9. Replace tools and equipment.
10. Clean the work area.

II-7-JS-6

JOB SHEET

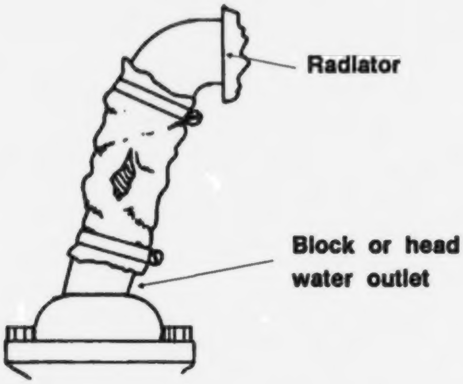
MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ DATE ____________________

UNIT:	Engine Cooling System
TOPIC:	Remove, Inspect and Replace Hoses
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to remove, inspect, and replace the hoses correctly.
TOOLS AND EQUIPMENT:	Common screwdriver/nut driver as needed Hose clamp pliers Drain container Fender cover Face shield
GENERAL INSTRUCTIONS:	Follow procedures to remove, inspect, and replace the hoses properly.
PROCEDURES AND/OR TASKS:	Check service/operator manual. **Note**: *Follow all safety rules.*

1. Place transmission in neutral/park and set parking brake.
2. Raise the hood and put on the fender cover.

3. Look at the hoses for signs of cracking, rot, hardness, softness, or collapsing. Any hose that has a hole, crack, or defect should be replaced.
   Note: *If hoses are more than four years old, it is a good idea to replace them.*



4. If necessary to replace hoses, drain the cooling system into a suitable container.

5. Remove the bad hose, using a common screwdriver or hose clamp pliers. If the hoses has bonded to the neck, it may be necessary to cut it off.
   Note: *The cooling system can be hot and under pressure. Remember safety rules and procedures from the previous lessons and follow them.*

6. Clean the neck with a wire brush to ensure a clean sealing surface. Compare the new hose to the old one, and trim the new hose if necessary.

7. Install the new hose, using new hose clamps. Tighten the hose clamps securely, using a common screwdriver or nut driver.

8. Refill the radiator.

9. Install the radiator cap.

10. Start the engine. Allow it to warm up, and check for leaks at hose fittings.

11. Have instructor check work.

12. Replace tools and equipment.

13. Clean the work area.

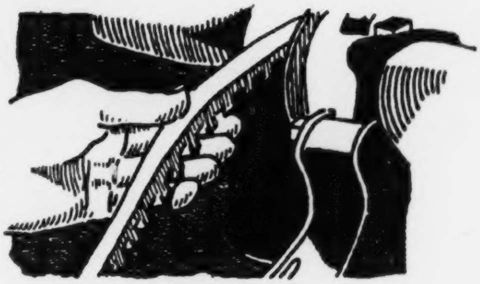
JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

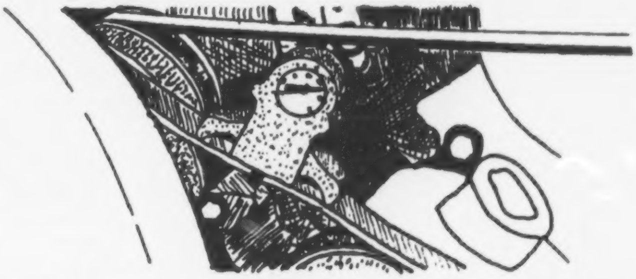
UNIT:	Engine Cooling System
TOPIC:	Inspect Fan Belts and Set Tension
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to inspect fan belts and set the tension.
TOOLS AND EQUIPMENT:	Tension gauge Straightedge Ruler Fender cover Open-end, box-end wrench set
GENERAL INSTRUCTIONS:	Follow procedures to inspect fan belts, and set the tension properly.
PROCEDURES AND/OR TASKS:	Check service/operator manual. **Note**: *Follow all safety rules.*

1. Place transmission in neutral/park and set parking brake.
2. Raise the car hood and put on the fender cover.
3. Look at all belts. Be sure to turn the belt over to see the bottom side.
   Note: *Look for fraying, glazing, cracks, splitting, and oil-soaked conditions. Fan belts that are over 4 years old should be replaced.*



4. If the belts have any of the conditions mentioned, replace the belts with new ones. The procedures for loosening, adjusting and retightening accessories will be found in the applicable auto manual.

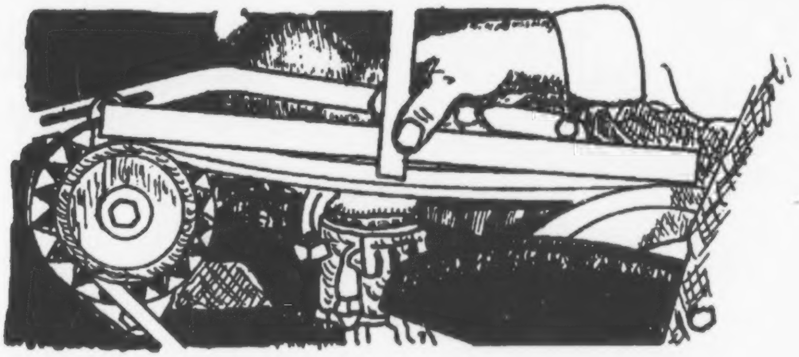
5. Using a belt tension gauge, check the belt tension to the specifications listed in the auto manual.



6. If a tension gauge is not available, lay a straightedge lengthwise on the belt.

7. Using a ruler in the middle of the straightedge, push down on the surface of the belt.

8. Read the distance from the belt to the straightedge.
   Note: *The reading should not exceed ½- to ⅝-in. Improper belt tension can cause bearing wear and premature failure of power steering, pump, alternator and water pump.*



9. Correct all belt tension.

10. Have instructor check work

11. Replace tools and equipment.

12. Clean the work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Engine Cooling System

TOPIC: Test, Remove and Replace Fan Clutch

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to test, remove, and replace the fan clutch.

TOOLS AND EQUIPMENT:
Open end wrench
Shop towel
Fender cover

GENERAL INSTRUCTIONS: Follow procedures to test, remove, and replace the fan clutch properly.

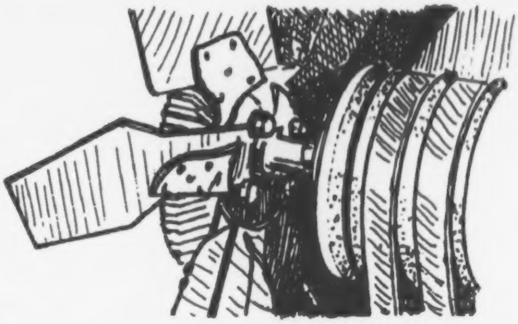
PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Place transmission in neutral/park and set parking brake. Start the engine and allow it to reach operating temperatures. You will know this point has been reached when the upper radiator hose becomes hot.

2. Turn the engine off, raise the car hood and put on the fender cover.

3. Put a shop towel on the blade of the fan and attempt to turn the fan opposite from the direction of rotation.
   Note: *If the fan is hard to turn, the fan clutch is all right. If the fan will spin more than 2 blades in the oposite direction of rotation, the clutch assembly is bad, and must be replaced.*

4. Using a suitable wrench, remove the four bolts that mount the clutch and fan blades to the water pump. Take care not to disturb the water pump pulley.



5. Remove the clutch and fan as a unit, and place them on the bench.
   Note: *Use care so you will not damage the radiator when removing the fan.*

6. Remove the four bolts that attach the fan to the clutch. Separate the fan from the defective clutch and discard the clutch, and four mounting bolts.

7. Place the new fan clutch on the fan.
   Note: *Use the new mounting bolts that come with the clutch.*

8. Align the clutch and fan with the holes on the water pump pulley.

9. Install the four mount bolts and tighten securely.

10. Check with the instructor and run the engine.

11. Shut down the engine and check the new fan clutch, using the same procedure as in step #3.

12. Have instructor check work.

13. Close the car hood.

14. Replace tools and equipment.

15. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Exhaust System

TOPIC: Exhaust System

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to examine and replace components of the exhaust system.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will test, remove, and replace components in the exhaust system and explain the purpose of each component.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with exhaust systems include mathematical principles and oral and written communication.*

Exhaust Systems

The exhaust system transfers burned gases from the combustion chamber to the atmosphere and reduces the exhaust noise to an acceptable level.

Terms and Definitions

Back pressure is a building up of exhaust gases because the muffler does not allow the burned gases to pass through freely.

Carbon monoxide is a poisonous gas within the exhaust gases.

Exhaust manifold is the collecting point of the burned gases as they leave the engine cylinders.

Exhaust pipe carries the gases to the muffler.

Hydrocarbons are the combination of hydrogen and carbon atoms that makes up petroleum base fuels—gasoline, kerosene, etc. The hydrocarbons make up almost 0.1 percent of engine exhaust emission.

Muffler is a device that silences the exhaust noises and routes the burned gases into the tail pipe.

Resonator is a device that further dampens the exhaust pulsations.

The route of exhaust gases is as follows:

- Exhaust gases are created by partial burning of the fuel-air mixture in the cylinders.
- Exhaust gases leave the cylinders through the valve port.
- After the gases leave the valve port, they collect in the exhaust manifold.
- The gases pass through a catalytic converter into the exhaust pipe.
  Note: *Some vehicles will have a catalytic converter at this point in the exhaust pipe.*
- The exhaust pipe transfers the gases to the muffler, where they are discharged to the atmosphere through a tail pipe.

The exhaust system tools and materials used are:

Pneumatic chisel is used in cutting welded mufflers free and in removing tail and exhaust pipes.

Hand-operated pipe cutter is used for cutting pipes smoothly.

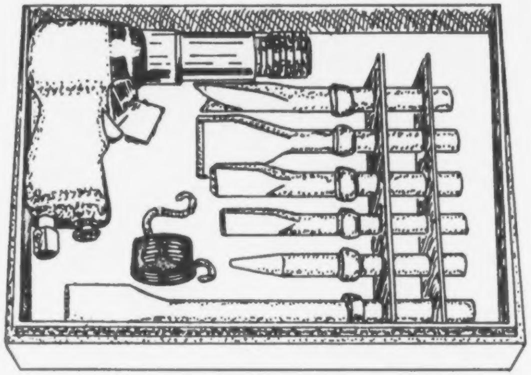
Pipe expanding tool is used to expand pipe ends for better joint fits.

Pipe end-straightening cone is used to straighten crimped or distorted pipe ends.

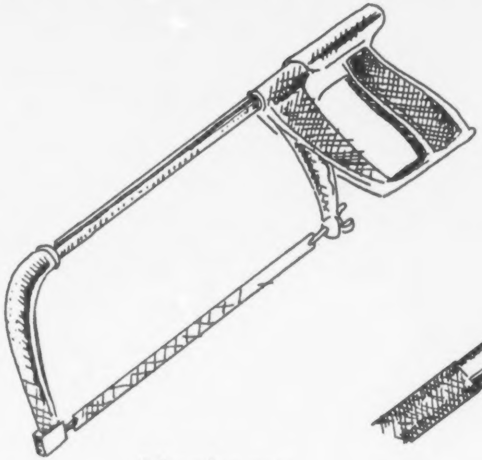
Chain wrench provides a good grip on pipe to help in pipe alignment or removal.

Penetrating oil helps in loosening fasteners and clamps.

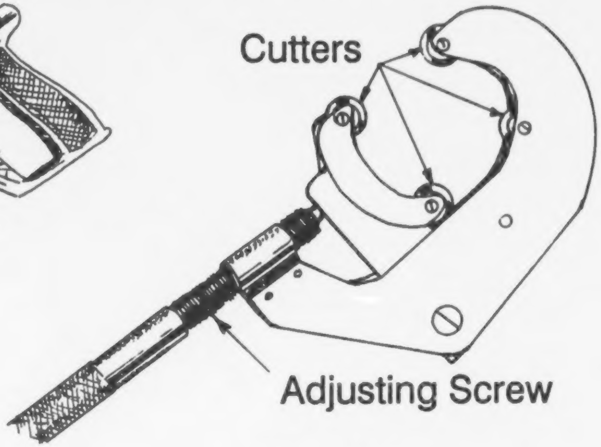
Exhaust System Tools



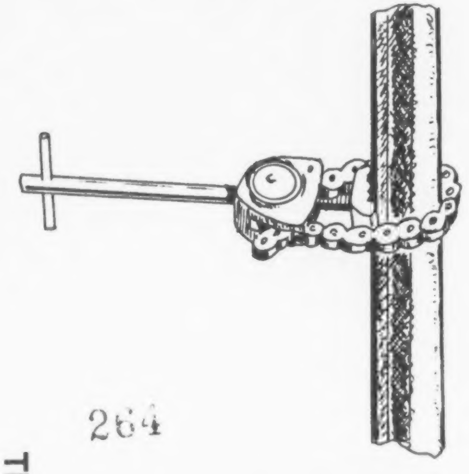
Pneumatic Chisel



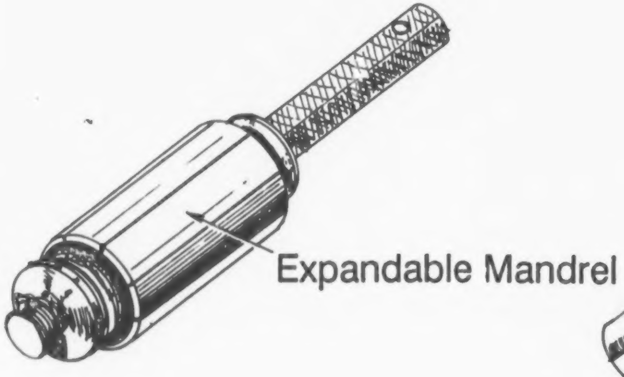
Hacksaw


Cutters
Adjusting Screw

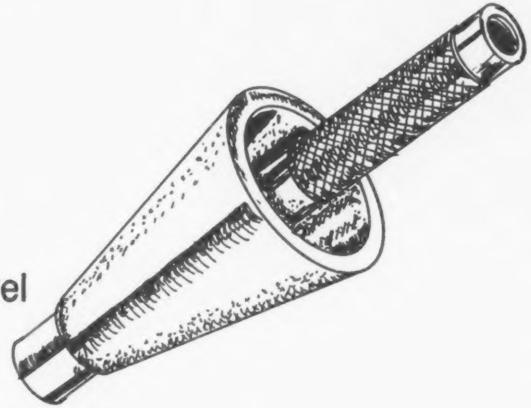
Pipe Cutter



Chain Wrench


Expandable Mandrel

Pipe Expanding Tool



Pipe End Straightening Cone

264

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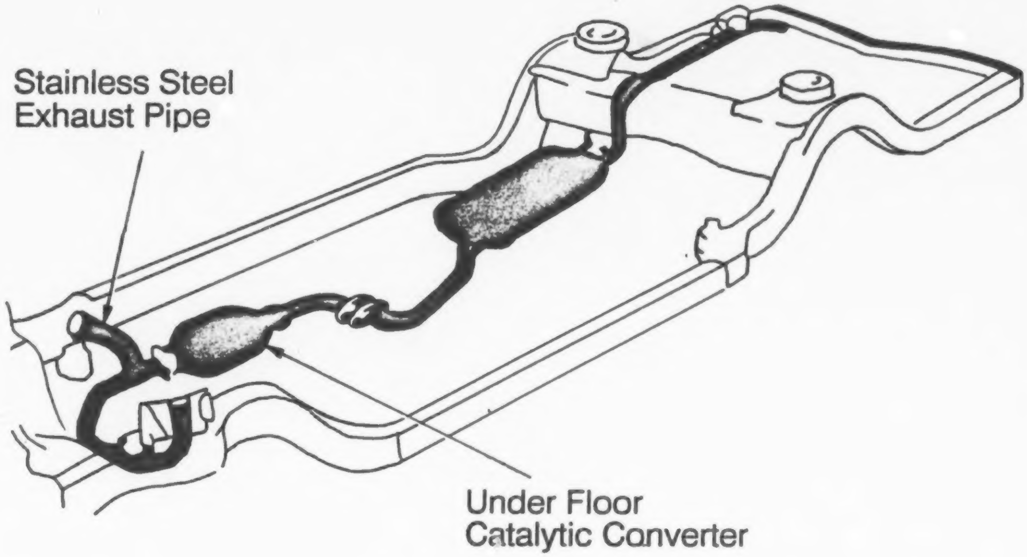
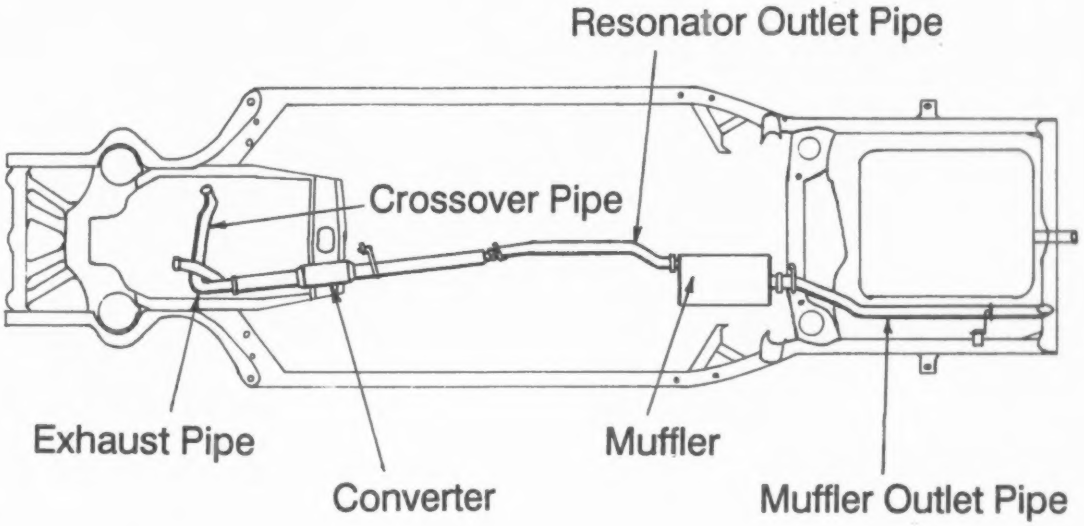
Emission Controls


Stainless Steel Exhaust Pipe
Under Floor Catalytic Converter

Exhaust System Components


Resonator Outlet Pipe
Crossover Pipe
Exhaust Pipe
Muffler
Converter
Muffler Outlet Pipe

ASSIGNMENT SHEET
MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ **DATE** ___________________

UNIT: Exhaust System

TOPIC: Exhaust System

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the exhaust system.

2. Match the terms and definitions associated with the exhaust system.

_____a. The collecting point of the burned gases as they leave the engine cylinders

_____b. Pipe that carries the gases to the muffler

_____c. A device that silences the exhaust noises and routes the burned gases into the tail pipe

_____d. A device used in addition to the muffler to further dampen exhaust pulsations

_____e. A building up of exhaust gases because the muffler does not allow the burned gases to pass through freely

_____f. A poisonous gas within the exhaust gases

1. Muffler
2. Carbon monoxide
3. Back pressure
4. Exhaust manifold
5. Exhaust pipe
6. Resonator

3. Determine the route of the exhaust gases from the time they are created to when they are discharged to the air by numbering the order of the following events.

_____a. The gases pass through a catalytic converter into the exhaust pipe.

_____b. Gases travel past the valve ports and collect in the exhaust manifold.

_____c. Exhaust gases are created by the partial burning of the fuel-air mixture in the cylinders.

_____d. The exhaust pipe transfers the gases to the muffler where they are discharged to the atmosphere through a tailpipe.

_____e. Exhaust gases leave the cylinders through the valve port.

4. Select the correct exhaust system tools and materials for each of the jobs associated with exhaust system repair.

_____a. Air tool used in cutting welded mufflers free and in removing tail and exhaust pipes

_____b. Used for cutting pipes smoothly

_____c. Used in heating pipe joints to loosen the connection

_____d. Used to expand pipe ends for better joint fits

_____e. Used to straighten crimped or distorted pipe ends

_____f. Provides a good grip on pipe to help in pipe alignment or removal

_____g. Allows the joints to slide together easier, assists in alignment, and prevents exhaust leaks

_____h. Helps in loosening fasteners and clamps

1. Pipe end straightening cone
2. Pneumatic chisel
3. Electric pipe joint heater
4. Penetrating oil
5. Chain wrench
6. Pipe expanding tool
7. Hand-operated pipe cutter
8. Exhaust system sealer

II-8-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT: Exhaust System

TOPIC: Change a Tail Pipe

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to change a tail pipe correctly.

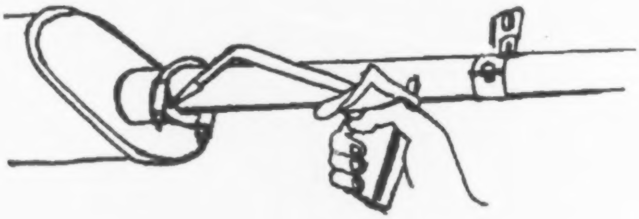
TOOLS AND EQUIPMENT:

- Pneumatic chisel
- Box-end wrench set
- Hydraulic jack
- Jack stands
- Wire brush
- File

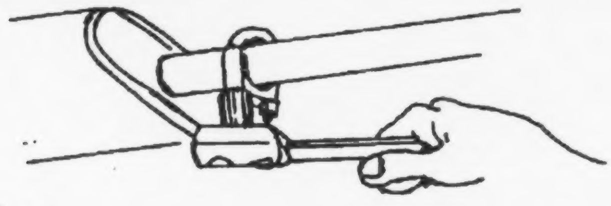
MATERIALS: Follow procedures to change a tail pipe properly.

GENERAL INSTRUCTIONS: Check service/operator manual.
Note: *Follow all safety rules, and wear eye protection.*

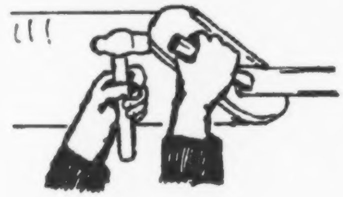
1. Raise the car enough to place jack stands.
2. Place jack stands under frame of car.
3. Use penetrating oil on nuts and bolts of clamps, fasteners, and brackets.

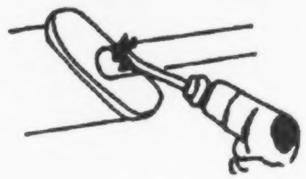


4. Remove all clamps and brackets holding tail pipe in place.
   Note: *If the penetrating oil does not loosen the nuts on the clamps and brackets, warm the nuts with the torch.*

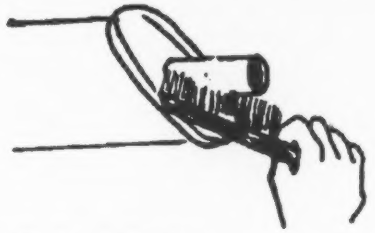


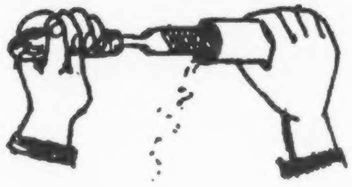
5. Remove tail pipe.
   Note: *If the pipe is stuck, use the power chisel to loosen the joint. Use eye protection!*





6. Clean the end of the muffler nipple with a wire brush or file.





7. Install the tail pipe.

8. Align the tail pipe and tighten the clamps and brackets.

9. Remove the jack stands and lower the car.

10. Place transmission in neutral and secure parking brake.

11. Start the engine and check for exhaust leaks.

12. Shut off engine.

13. Have instructor check work.

14. Replace tools and equipment.

15. Clean the work area.

II-8-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Exhaust System

TOPIC: Change Muffler

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to change the muffler.

TOOLS AND EQUIPMENT:

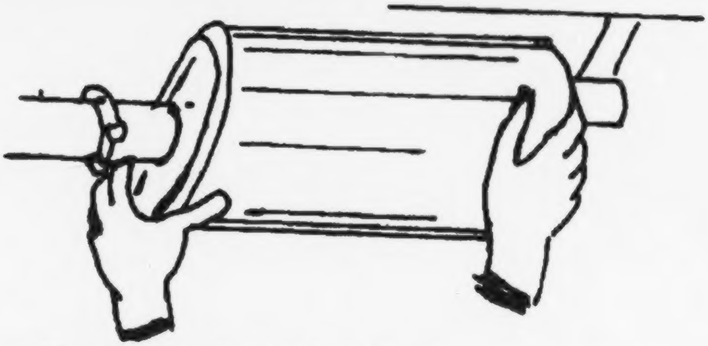
- Power chisel
- Box-end wrench set
- Hydraulic jack
- Jack stands
- Wire brush
- File
- Exhaust system sealer

GENERAL INSTRUCTIONS: Follow procedure to change the muffler properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules, and wear eye protection.*

1. Raise the car enough to place jack stands.
2. Place jack stands under frame of car.
3. Use penetrating oil on nuts and bolts of clamps and fasteners.
4. Remove tail pipe.
   Note: *Follow procedure in Job Sheet #1.*
5. Remove pipe clamp between the exhaust pipe and muffler.
6. Remove the muffler.

7. Straighten the end of the exhaust pipe.
8. Slide the new muffler inlet nipple onto the exhaust pipe.



9. Align the muffler and install the pipe clamp.
   Note: *If pipe clamps or brackets are badly rusted, replace them.*
10. Install the tail pipe.
11. Align the tail pipe and tighten clamps and brackets.
12. Remove jack stands and lower the car.
13. Place transmission in neutral/park and secure parking brake.
14. Start the engine and check for exhaust leaks.
15. Shut off engine.
16. Have instructor check work.
17. Replace tools and equipment.
18. Clean work area.

STUDENT INFORMATION SHEET

MINOR AUTOMOTIVE MAINTENANCE

UNIT: Wheels and Tires

TOPIC: Wheel and Tire Terminology

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to discuss the care and handling of wheels and tires.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will inspect, test, and service wheels and tires.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with wheels and tires include mathematical principles, oral and written communications and reading concepts.*

Terms and Definitions

The **lug bolt** and **nut** are the fasteners that hold the wheel to the hub.

The **mag wheel** is made of light alloy metals, usually lightweight and sporty, and comes in various sizes.

The **safety rim** has two safety ridges to prevent the tire from leaving the rim in the event of a blowout.

Static balancing is the even distribution of weight around the wheel rim. The mechanic uses a bubble balancer to find the heavy spot and applies tire weight(s) to balance it out.

The **tire sidewall** is the part between the tread and bead.

The **tire tread** is the flat rubber part that gets most of the wear and tear. The tread design helps to grip the road and to resist puncturing.

The **tramp** is the front tire hopping up and down.

The **wheel balancer** is the machine that balances wheels and eliminates some of the principle causes of tire wear.

Safety Rules

Always wear safety glasses.

Always use jack stands when car is lifted.

Place jacks and stands in a secure position.

Torque lug nuts in sequence.

Replace tires when the tread wear indicators become visible. These are ridges that run perpendicular to the tread. When the tread wears down to 2/32-in., the indicators show up as a solid bar running across the tread.

Keep front end aligned.

Rotate tires at proper intervals (according to owner's manual).

Use extreme care when inflating tire.

Keep hands and fingers from between bead and flange when inflating tire.

Observe tire wear patterns.

Inflate tires to correct pressure. Do not overinflate.

Use a lubricant when mounting tires.

Use new cotter pin in hub nut.

Tighten hub nuts according to the procedure given in the shop manual.

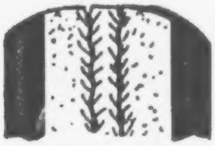
When packing wheels with grease, always replace a bearing in the same wheel from which it was removed.

Remember hand-tool safety rules.

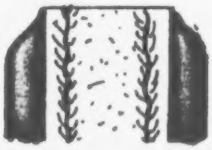
Wheel damage can include dents, cracks, excessive wear in bolt holes, burrs and warpage.

Causes of improper tire wear are shown below:

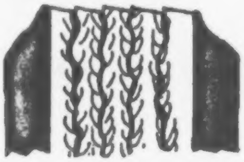
A. Under-inflation



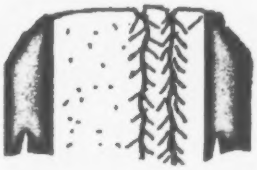
B. Over-inflation



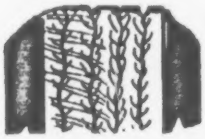
C. Incorrect toe-in
or toe-out adjustment



D Incorrect camber adustment



E. Excessive cornering speed



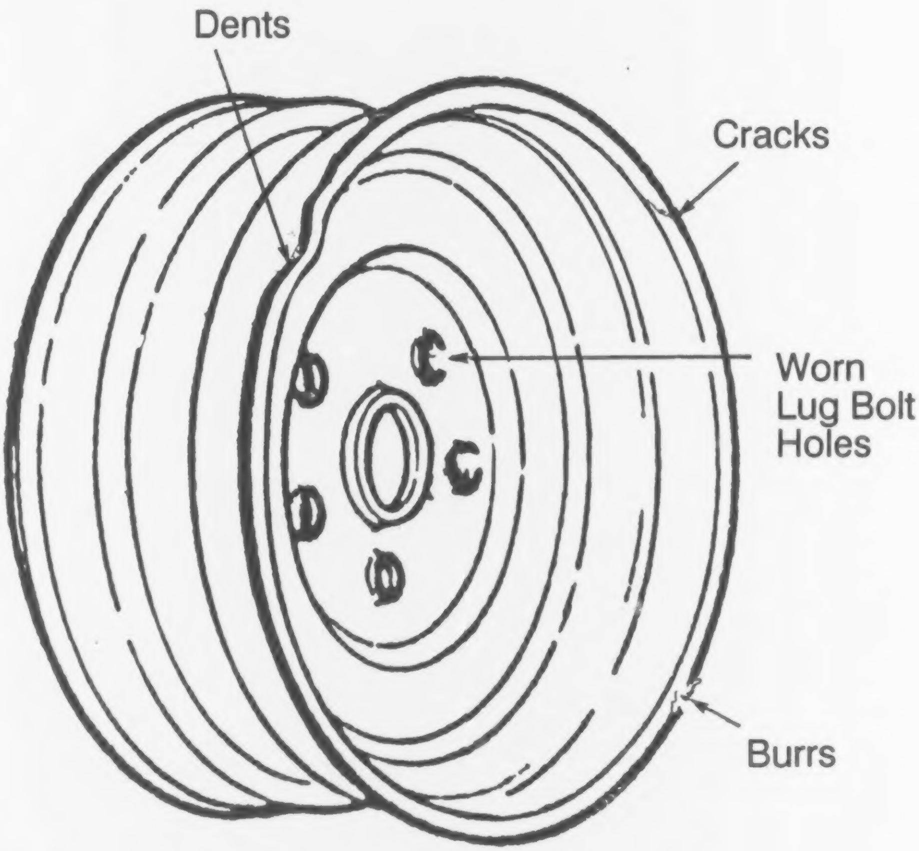
Tire Rotation

The purpose of tire rotation is to make the tires wear evenly. Manufacturers say you can get up to 20 percent more wear if you rotate the tires. Distinctive tread wear patterns provide clues to poor alignment, worn shock absorbers, and defective brakes. If the tread does not show any of these problems, then rotate the tires. It is a good idea to balance the wheels each time tires are rotated.

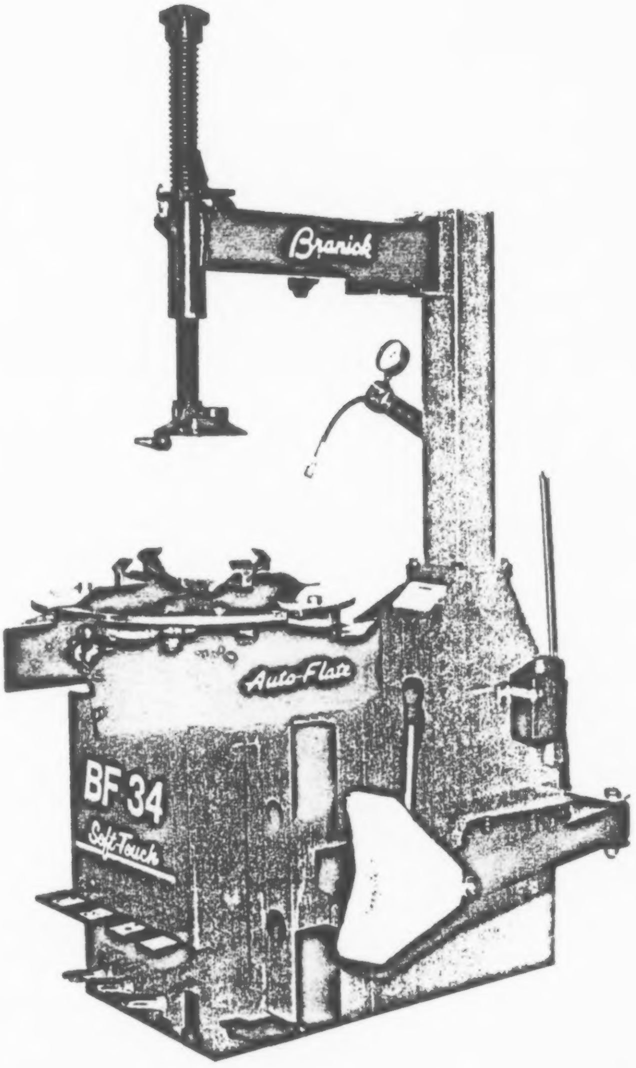
Wheel balancing will help eliminate some of the causes of tire wear. Some service stations have computerized balancers that will not only balance the wheels but will also locate the places where the weights are needed and decide how much weight to add.

If you have radial ply tires, you should not move tires from one side to the other; radial remain on the same side of the car and are moved from front to rear.

Wheel Damage

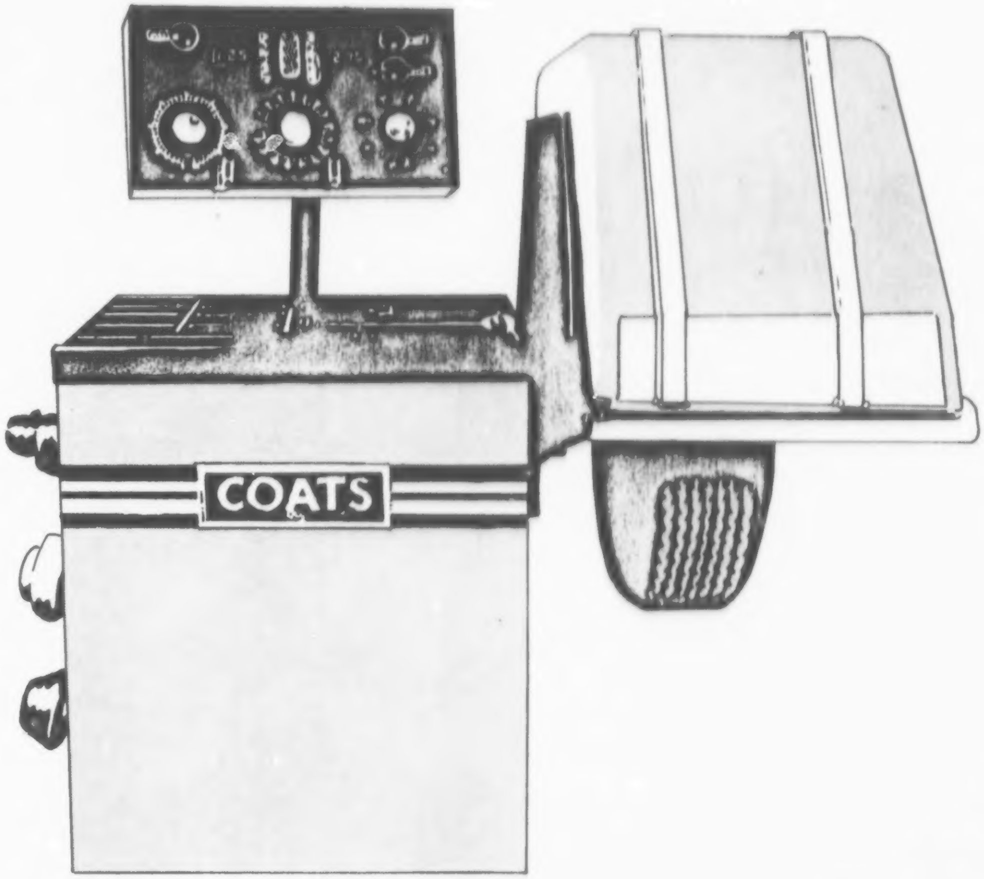

Dents
Cracks
Worn Lug Bolt Holes
Burrs

Tire-Changing Equipment

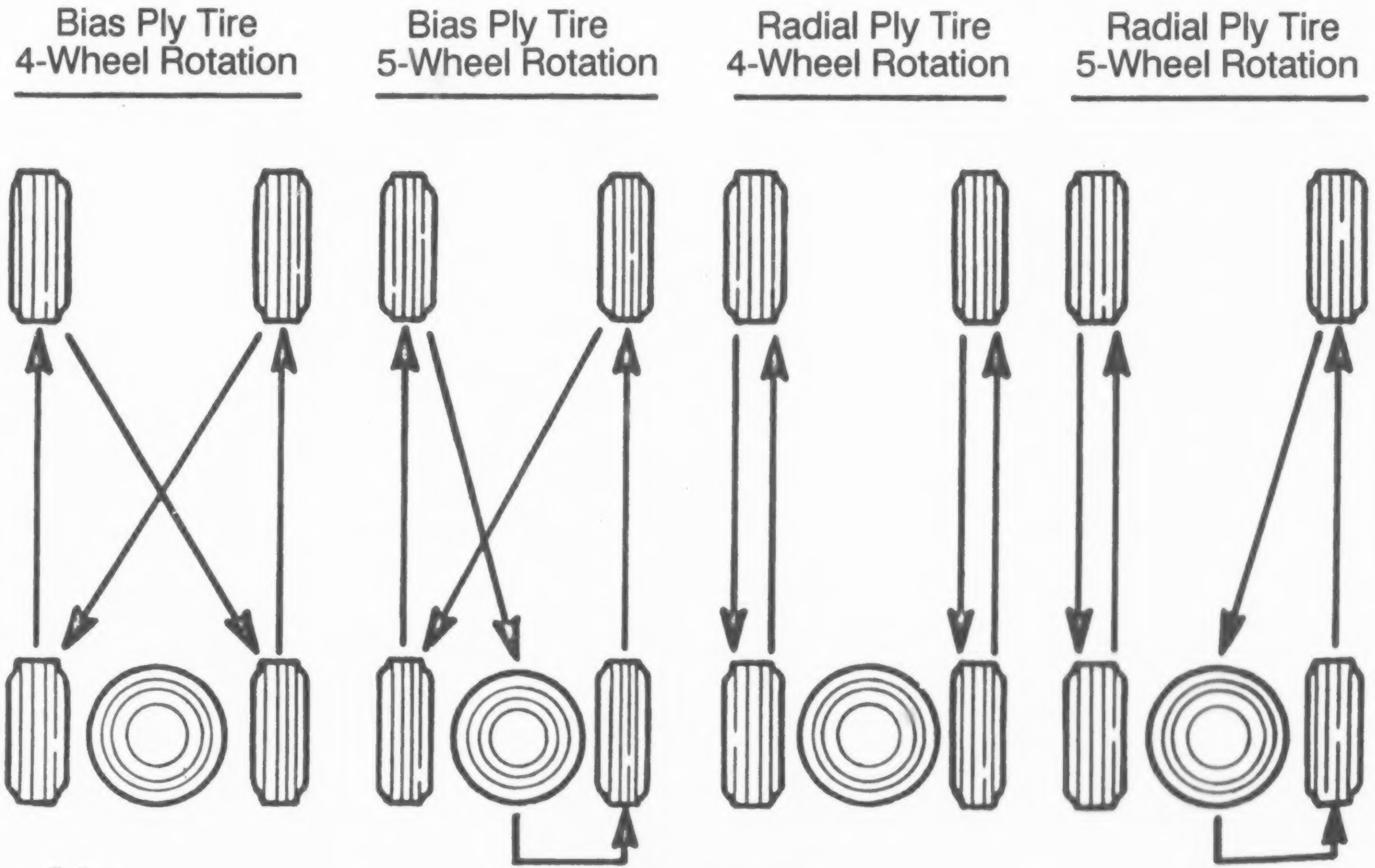

Branick
Auto-Flate
BF 34
Soft-Touch

The bead breaker

Balancing Tire and Wheel



Tire Rotation


Bias Ply Tire
4-Wheel Rotation
Bias Ply Tire
5-Wheel Rotation
Radial Ply Tire
4-Wheel Rotation
Radial Ply Tire
5-Wheel Rotation

Tire rotation diagrams

II-9-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Wheels and Tires

TOPIC: Wheel and Tire Terminology

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms on the right to the correct definition:

______a. A wheel made of light alloy metal; usually lightweight, sporty, comes in many sizes

______b. Rim having two safety ridges, to prevent the tire from leaving the rim in event of blowout

______c. Even distribution of weight around the axis of rotation

______d. Balancing for both static and dynamic balance

______e. Part of tire between tread and bead of tire

______f. Part of tire that contacts the road

______g. Condition that causes front tires to hop up and down

______h. Fasteners that hold the wheel to the hub

______i. Machine on which to balance wheels

1. Mag wheel
2. Safety rim
3. Tire sidewall
4. Tramp
5. Dynamic balance
6. Static balance
7. Wheel balancer
8. Wheel tread
9. Lug bolt and nut

2. Select the proper safety rules associated with wheels, and tires by placing a "√" in front of each that is correct.

______a. Use jack stands only when the complete car is lifted off the ground.

______b. Place jack stands anywhere they will easily fit.

______c. Tighten lug nuts securely.

______d. Do not replace tires until they become slick.

______e. Keep the front end aligned.

______f. Rotate tires at 5,000 mile intervals.

______g. Inflate tires rapidly because there is no danger.

______h. Keep hands and fingers from between bead and flange when inflating tires.

______i. Observe tire wear patterns.

______j. Inflate tires until they feel tight.

______k. Use a rubber lubricant only when mounting new tires.

______l. Hand-tool safety does not apply to tire changing.

3. List five faults you may find when inspecting a damaged wheel.

a.

b.

c.

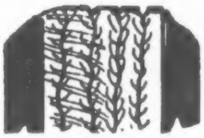
d.

e.

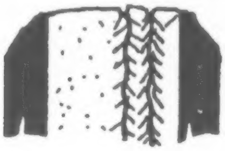
4. Determine the causes of improper tire wear by writing one of the following conditions by each illustration.

Under-inflation	Incorrect toe-in or toe-out adjustment
Over-inflation	Incorrect camber adjustment
Excessive cornering speed	

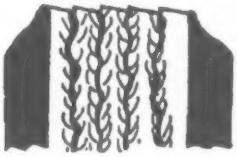
a.____________________



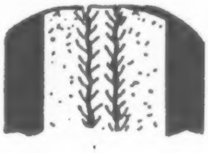
b.____________________



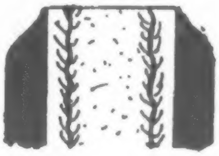
c.____________________



d.____________________



e.____________________



5. Name the method of repairing a punctured tire.

6. Explain the purpose of rotating tires.

II-9-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Wheels and Tires

TOPIC: Remove and Install a Wheel

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and install a wheel correctly.

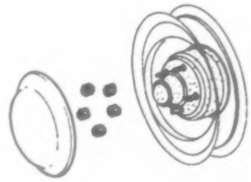
TOOLS AND EQUIPMENT:

Hydraulic floor jack
Jack stand
Lug wrench as required
Shop rag
Large screwdriver
Rubber mallet
Torque wrench

GENERAL INSTRUCTIONS: Follow procedures to remove and install a wheel properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Set parking brake and chock wheels.
2. Raise car where wheel is to be removed.
3. Place jack stand under car in secure location.
4. Remove hub cap.
5. Remove lug nuts.
   Note: *Place in hub cap.*
6. Remove the wheel.



7. Check the wheel for damage.
   Note: *See Job Sheet #2 for checking procedures.*

8. Install a good wheel and tire.

9. Put on lug nuts and tighten torque to specifications.

10. Install hub cap.
    Note: *Use rubber mallet.*

11. Have instructor check work.

12. Remove jack stand.

13. Lower car to floor.

14. Replace tools and equipment.

15. Clean the work area.

II-9-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Wheels and Tires

TOPIC: Inspect a Wheel for Damage

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to inspect a wheel for damage.

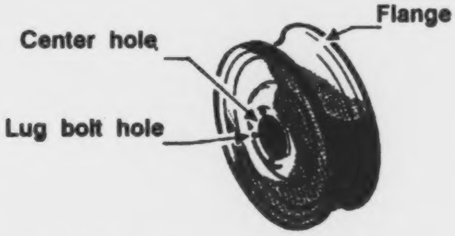
TOOLS AND EQUIPMENT:
Wire brush
Shop rag
Cleaning vat
Wheel weight tool
Car wheel

GENERAL INSTRUCTIONS: Follow procedures to inspect a wheel for damage properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Remove any wheel weights with the wheel weight tool.
2. Clean wheel with wire brush and cleaning vat. Dry thoroughly.
3. Check the rim for dents, burrs, cracks, or any other damage.
4. Check wheel bolt holes for cracks and excessive wear.

5. Check flanges for dents and cracks.


Flange
Center hole
Lug bolt hole

6. Check the center hole for damage.
7. Report any damage to the instructor.
8. Have instructor check work.
9. Replace tools and equipment.
10. Clean the work area.

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JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Wheels and Tires

TOPIC: Remove Tire from Rim

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

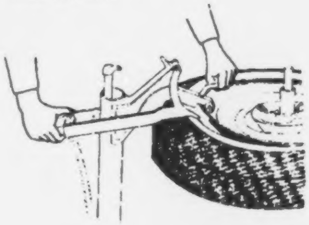
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove a tire from the rim.

TOOLS AND EQUIPMENT:
Tire mounting and demounting equipment
Rubber lubricant or soapy water
Tire tools necessary for tire equipment
Shop rag
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to remove a tire from the rim properly.

PROCEDURES AND/OR TASKS: Check service/operator manual
Note: *Follow all safety rules.*

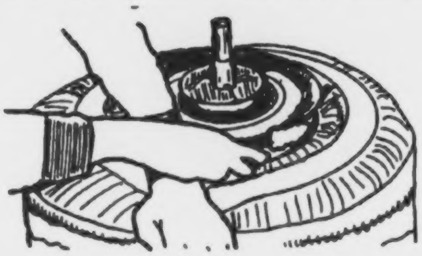
1. Place the wheel on the tire changer.
2. Tighten the nut securely.
3. Mark tire and valve stem location.



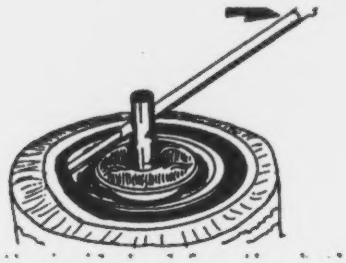
4. Break the bead down from the sealing surfaces.

5. If the tire equipment does not break both beads, turn the tire over and break the bead down.

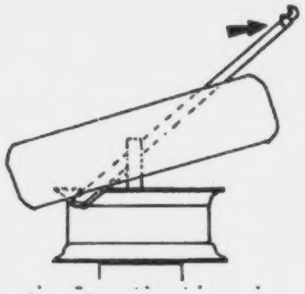
6. Apply rubber lubricant to the beads of the tire and on the rim edge.



7. Using the bead remover bar on the tire equipment, remove the outside bead from the wheel.



8. Remove the inside bead from the wheel.



9. Remove the rim from the tire changer.

10. If a new tire is to be installed, go to the procedures outlined on Job Sheets #4 and #6.

11. Have instructor check work.

12. Replace tools and equipment.

13. Clean the work area.

II-9-JS-4

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ **DATE** __________________

UNIT: Wheels and Tires

TOPIC: Install Tire on a Rim

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to install a tire on the rim correctly.

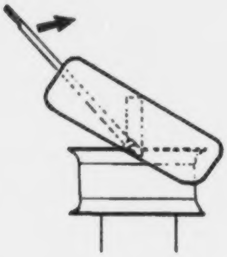
TOOLS AND EQUIPMENT:
Tire mounting and demounting equipment
Rubber lubricant or soapy water
Tire tools necessary for tire equipment
Shop rag
Bead expander
Tire pressure gauge
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to install a tire on the rim properly.

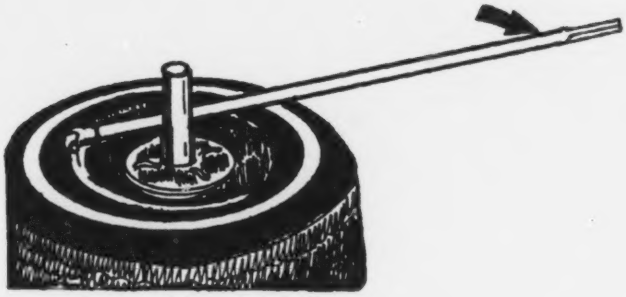
PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules and safety precautions with special wheels.*

1. Place rim on tire changer and tighten nut securely.
2. Clean the rim along the bead-sealing surfaces.
3. Apply rubber lubricant around the sealing surfaces of the rim.
4. Lay the tire on the rim.

5. Install the inner bead on the rim.



6. Install the outer bead on the rim.



7. Loosen the rim hold down nut before inflating the tire.

8. Inflate the tire to the recommended pressure.
   Note: *If the bead and rim will not seal, use the bead expander to seat the bead only. Remove the bead expander before the pressure reaches 10 pounds.*

9. Remove the tire from the tire changer.

10. Have instructor check work.

11. Replace tools and equipment.

12. Clean the work area.

II-9-JS-5

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ____________________ **DATE** ____________

UNIT: Wheels and Tires

TOPIC: Repair a Punctured Tire

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to repair a punctured tire correctly.

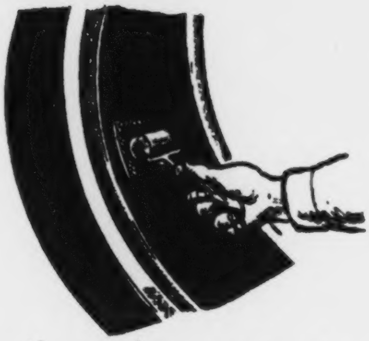
TOOLS AND EQUIPMENT:
Patch
Rubber cement
Scissors
Tire-patching tools
Tire pressure gauge
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to repair a punctured tire properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Inflate the tire to the correct pressure, and use the water tank or a spray-on soap and water solution to locate the leak. Mark the spot with chalk.
2. Clean the punctured area inside the tire with tire solvent.
   Note: *Refer to Job Sheet #3 for tire dismounting procedures.*
3. Rub the area with the tire abrading tool. If this tool is unavailable, an air drill with a grinding stone can be used.
4. Apply rubber cement to the area where the patch will lay.
5. Place the patch over the puncture.

6. Roll it down firmly.



7. Replace tire on rim. Refer to Job Sheet #4 for tire mounting procedures.

8. Have instructor check work.

9. Replace tools and equipment.

10. Clean the work area.

II-9-JS-6

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Wheels and Tires

TOPIC: Balance a Wheel and Tire

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to statically balance a wheel and tire correctly.

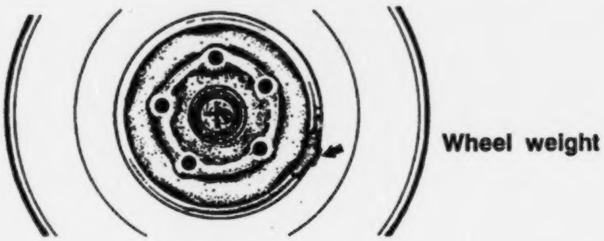
TOOLS AND EQUIPMENT:
Tire balancer
Wheel weights
Wheel weight hammer
Chalk
Safety Glasses

GENERAL INSTRUCTIONS: Follow procedures to statically balance a wheel and tire properly.

PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

1. Remove all weights and dirt from the wheel.
   Note: *Special wheels, such as mags and custom alloy wheels, require special weights.*
2. Place wheel on balancer.
   CAUTION: Do not drop the wheel in place.
3. Engage the balancer by moving the level to the left.
4. Observe the position of the bubble.

5. Place a wheel weight of the approximate size on the wheel flange.
   Note: *The weight should be on the same side of the circle as the bubble.*



6. Divide the weights into two parts, if necessary, to balance the tire.

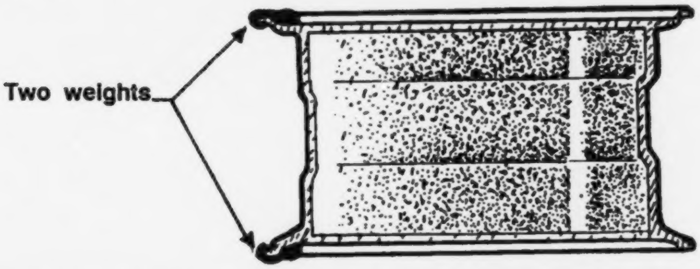
7. Mark across the tread of the tire at each weight.

8. Disengage the balance lever.

9. Remove the wheel from the balancer.

10. Take each weight amount and divide by two. This gives the weight amount to be attached to each side wheel.

11. Hammer these weights in place on each side of flange in line with the correct mark or marks.



12. Recheck the wheel for proper balance (repeat steps #2 - #4).

12. Have instructor check work.

13. Replace tools and equipment.

14. Clean the work area.

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II-9-JS-7

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Wheels and Tires

TOPIC: Rotate the Tires Including Spare

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to rotate bias-ply tires, including the spare.

TOOLS AND EQUIPMENT:

Hydraulic floor jack
Four jack stands
Lug wrench or impact wrench
Rubber mallet
Large common screwdriver
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to rotate the tires properly.

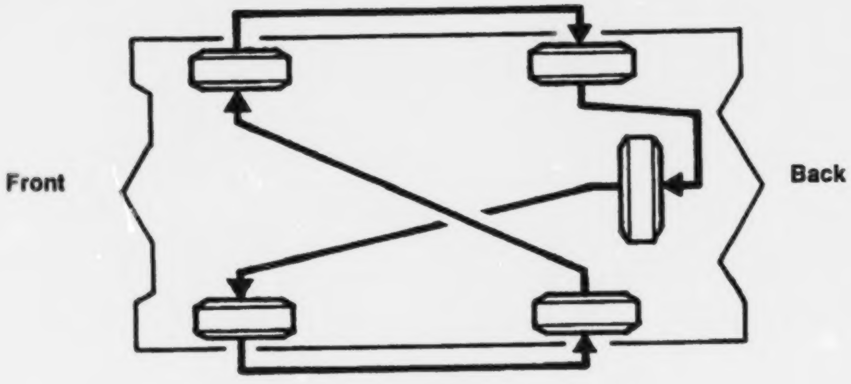
PROCEDURES AND/OR TASKS: Check service/operator manual.
Note: *Follow all safety rules.*

Note: *This procedure is used on bias-ply tires only. Radials tires are rotated front to rear.*

1. Place vehicle on jack stands.
2. Remove the hubcaps with the large screwdriver.
3. Remove the lug nuts with the lug wrench.
4. Remove the spare tire and wheel from the trunk or rack.
5. Mount the spare on the left front.

6. Mount the left front on the left rear.

7. Mount the left rear on the right front.



Bias or Belted Bias

8. Mount the right front on the right rear.

9. Place the right rear tire and rim in the trunk or on the rack.

10. Tighten all lug nuts securely.

11. Install the hubcaps using the rubber hammer.

12. Remove the jack stands.

13. Lower the car to the floor.

14. Have instructor check work.

15. Replace tools and equipment.

16. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Brake and Bearing Systems

TOPIC: Brake and Bearing System Terminology and Components

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(D)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to discuss, service and replace components of drum, disc brake and bearing systems.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to service, remove and replace components in the braking system and dispose of brake waste material.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with brake and bearing system include mathematical principles, reading concepts, oral and written communications, and science.*

Purpose of Braking

The brake system applies hydraulic pressure in the system, which produces friction between the brake shoe and drum, causing the automobile to slow or stop at any time during operation.

Terms and Definitions

Bleeding the brakes removes air from the hydraulic system.

Booster is placed in a braking system to increase the pressure output and decrease the amount of effort required to operate the brakes.

Brake backing plate is a rigid steel plate to which brake shoes are attached.

Brake drum is a cast iron or aluminum housing, bolted to the wheel, that rotates around the brake shoes and gives a surface for the brake shoes to rub against.

Brake fade is a reduction in braking force due to loss of friction between brake shoes and drum, caused by heat buildup.

Brake fluid is a special fluid designed for the hydraulic brake systems.

Braking ratio is the transfer of weight from the rear to the front of the vehicle, during brake application. On average, braking ratio is 55% to 60% front and 40% to 45% rear of the stopping force.

Brake shoes are a part of the brake system with an attached brake lining. Friction is created when the lining comes into contact with the brake drum.

Caliper is a clamping device which holds the wheel cylinder and pads on the disc brake.

Disc brakes use a steel disc with a caliper type of lining holder instead of the internal brake shoe type.

Friction is the force acting between two bodies at their surface contact so as to resist their sliding upon each other.

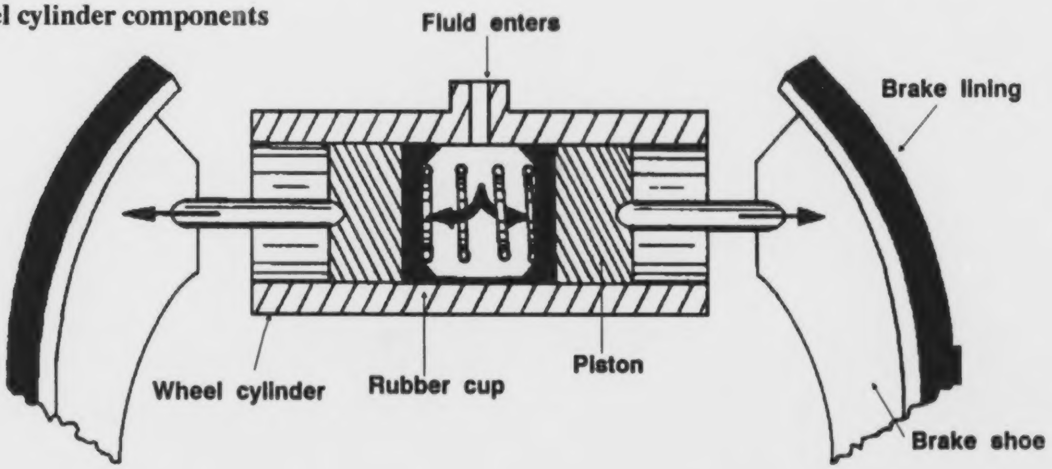
Heat energy is created in the internal combustion engine to power the vehicle. Heat energy is changed into kinetic energy while the vehicle is in motion. The kinetic energy is changed back into heat energy to stop the vehicle through friction in the brake system.

Master cylinder is the part of the hydraulic system in which pressure is generated.

Pads are a type of brake lining used with disc brakes.

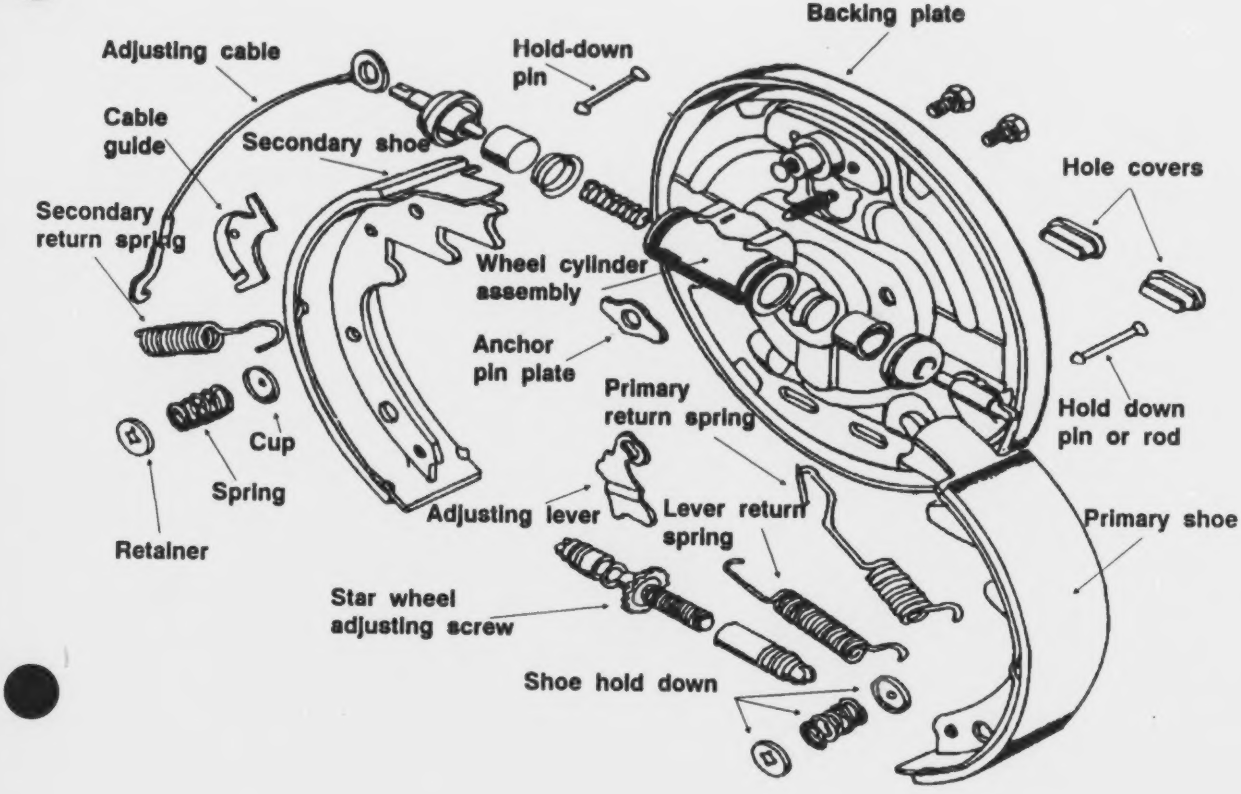
Wheel cylinder receives pressure from the master cylinder and applies it to brake shoes in the brake drum.

Wheel cylinder components



300

Brake mechanism components


Adjusting cable
Hold-down pin
Backing plate
Cable guide
Secondary shoe
Hole covers
Secondary return spring
Wheel cylinder assembly
Anchor pin plate
Primary return spring
Hold down pin or rod
Cup
Spring
Retainer
Adjusting lever
Lever return spring
Primary shoe
Star wheel adjusting screw
Shoe hold down

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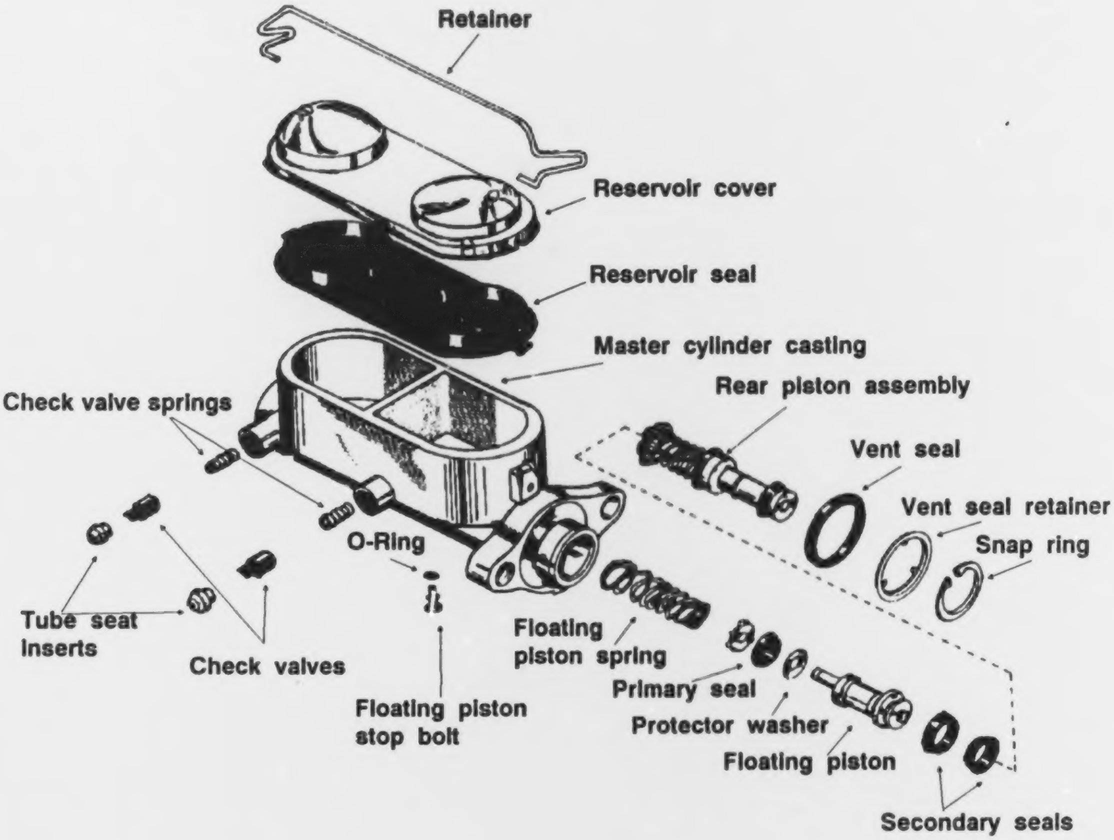
Master cylinder components


Retainer
Reservoir cover
Reservoir seal
Master cylinder casting
Rear piston assembly
Check valve springs
Vent seal
Vent seal retainer
Snap ring
O-Ring
Tube seat inserts
Check valves
Floating piston spring
Primary seal
Floating piston stop bolt
Protector washer
Floating piston
Secondary seals

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Disc Systems

The disk brake system utilizes a disc (rotor) with brake pads positioned on either side of it. The disc (rotor) is a casting which may be equipped with cooling fins between the two braking surfaces. Fins enable air to circulate between the braking surface making them less sensitive to heat buildup and more resistant to fade. Contaminates such as dirt and water do not affect braking because of the centrifugal action of the rotor. The braking action of the pads ensures uniform straight stops. The disc brakes are inherently self-adjusting.

The disc brakes metering valve will keep pressure from traveling to the disc on the front wheels until the brake shoes on the rear wheels contact the drums, ensuring that the front brakes are never used alone.

Waste Disposal of Brake Material

The asbestos dust thrown from the brake lining or disc pads may be dangerous if inhaled. Never use compressed air or your own breath to blow the dust from the brake assembly. Use an aerosol brake cleaner, damp rag or a vacuum cleaner with an approved asbestos filter. Dispose of the rag or cleaner bag properly. Do not move a vehicle until a firm brake pedal is obtained.

Safety with Brake System

Use **proper tools** and **equipment** to prevent damage to the system and personal injury.

Wear **safety glasses** while doing all types of brake work. Metal chips from brake parts, springs and the brake lathe can damage the eyes. Dirt from under the vehicle or from hydraulic brake fluid can irritate the eyes.

Keep **oil** and **grease** off all brake parts such as drums, disc rotors, linings and pads to prevent glazing and defective brakes.

Only use **denatured alcohol** to clean brake parts. Solvent, gasoline and kerosene will deteriorate rubber parts and cause fluid leakage.

Use only **quality** parts and brake fluid to prevent failures in brake systems.

Brake fluid causes damage to painted surfaces and irritates the skin and eyes. Extreme care should be used when working around hydraulic brake fluid. If spillage occurs, flush with clear water.

Be **positive** each unit of the brake system is assembled correctly when making repairs. Incorrect installation leads to improper braking action causing components to fail prematurely.

Be sure to **test drive** the vehicle every time adjustments or repairs are made on the brake system for proper system operation.

Bearing Systems

Front wheel bearings come in pairs—the inner and outer bearings. The bearings allow your wheel to turn freely over thousands of miles. It cushions the contact between the wheel and spindle it sits on with frictionless bearings and a lot of grease. It is important to check the bearings when the brakes are checked. When packing the bearings, be sure there is no dust or dirt in the grease. The best time to repack your wheels is when a **front end alignment** or **brake job** is done. This is because the wheels will be off and easy to check.

There are no wheel bearings on the rear wheels. There are axle bearings that must be replaced when they wear out. They cannot be repacked.

Terms and Definitions

The **ball bearing** consists of an inner and outer hardened steel race separated by a series of hardened steel balls.

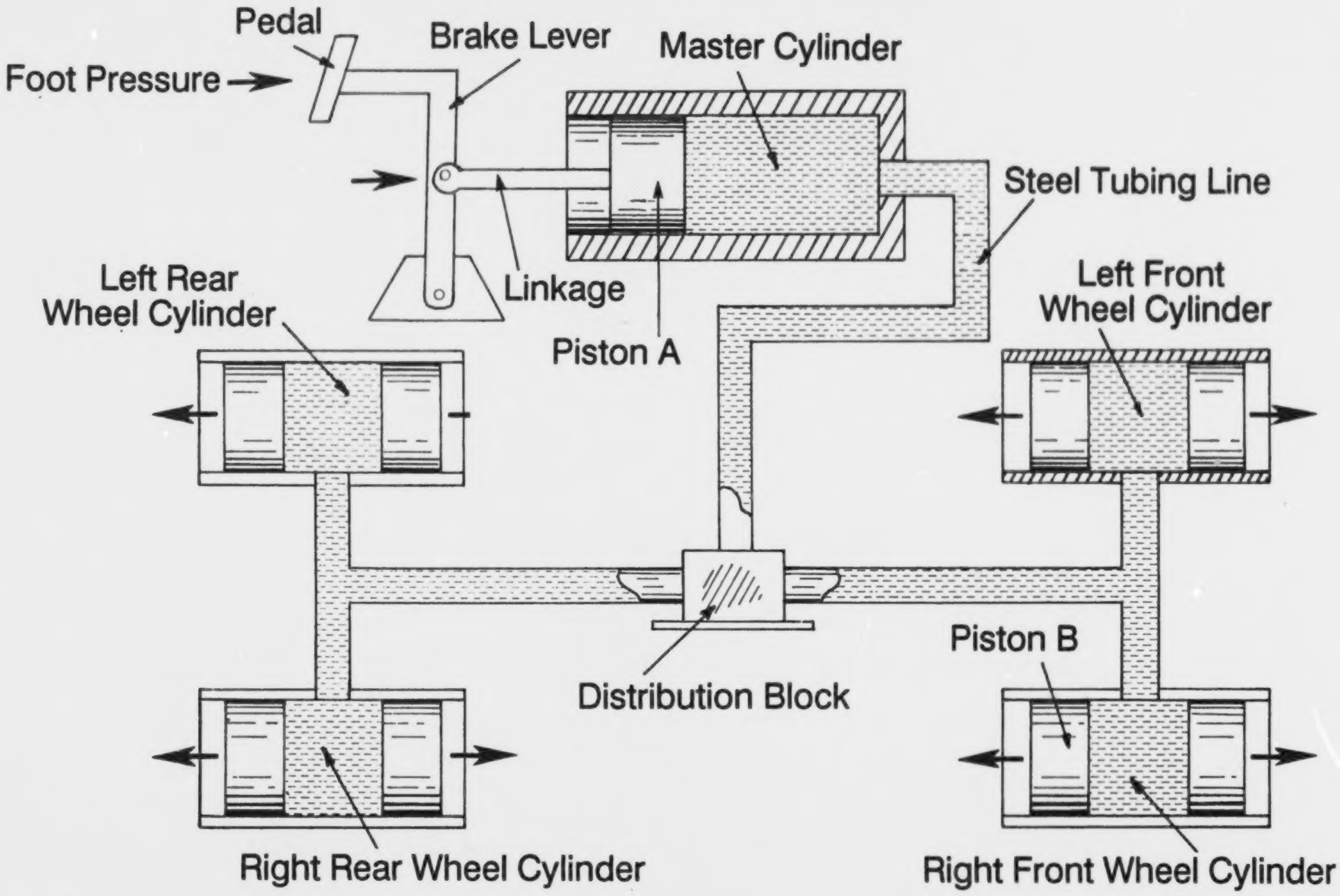
The **cotter pin** is a fastener shaped like a pin but split in the center. After insertion, the legs are bent up or around to keep it in place.

The **race** has an inner or outer ring that provides a contact surface for balls or rollers in bearings.

The **sealed bearing** has been lubricated at the factory and then sealed. It cannot be lubricated during service.

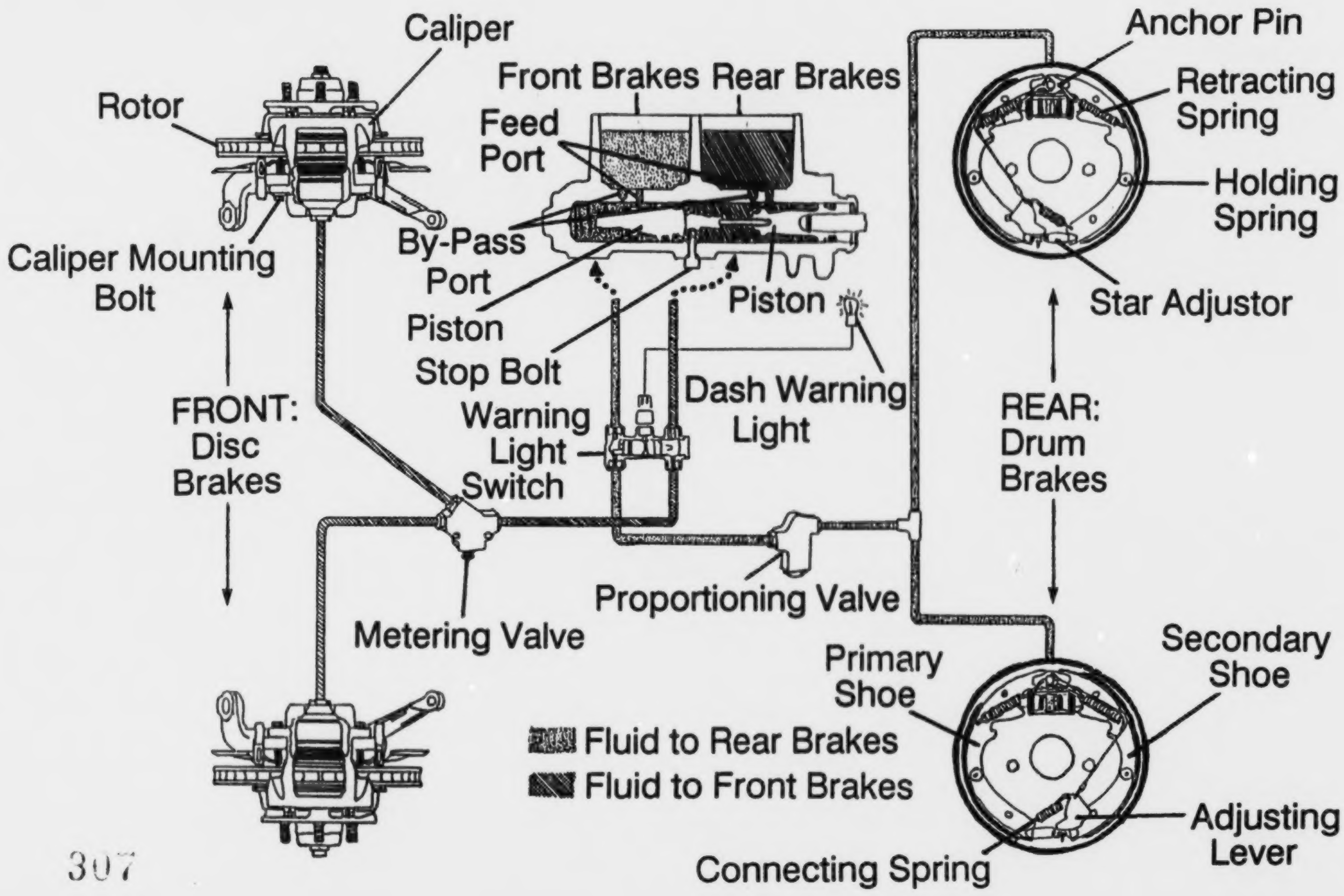
The **tapered roller bearing** utilizes a series of tapered, hardened steel rollers operating between an outer and inner hardened steel race.

The Hydraulic Principle


Pedal
Brake Lever
Master Cylinder
Foot Pressure
Steel Tubing Line
Linkage
Left Rear Wheel Cylinder
Piston A
Left Front Wheel Cylinder
Piston B
Distribution Block
Right Rear Wheel Cylinder
Right Front Wheel Cylinder

TM-1

Combination Disc Front/ Drum Rear System


Caliper
Rotor
Front Brakes
Rear Brakes
Feed Port
Caliper Mounting Bolt
By-Pass Port
Piston
Stop Bolt
Piston
FRONT: Disc Brakes
Warning Light Switch
Dash Warning Light
Metering Valve
Proportioning Valve
Anchor Pin
Retracting Spring
Holding Spring
Star Adjustor
REAR: Drum Brakes
Primary Shoe
Secondary Shoe
▨ Fluid to Rear Brakes
▨ Fluid to Front Brakes
Connecting Spring
Adjusting Lever

TM-2

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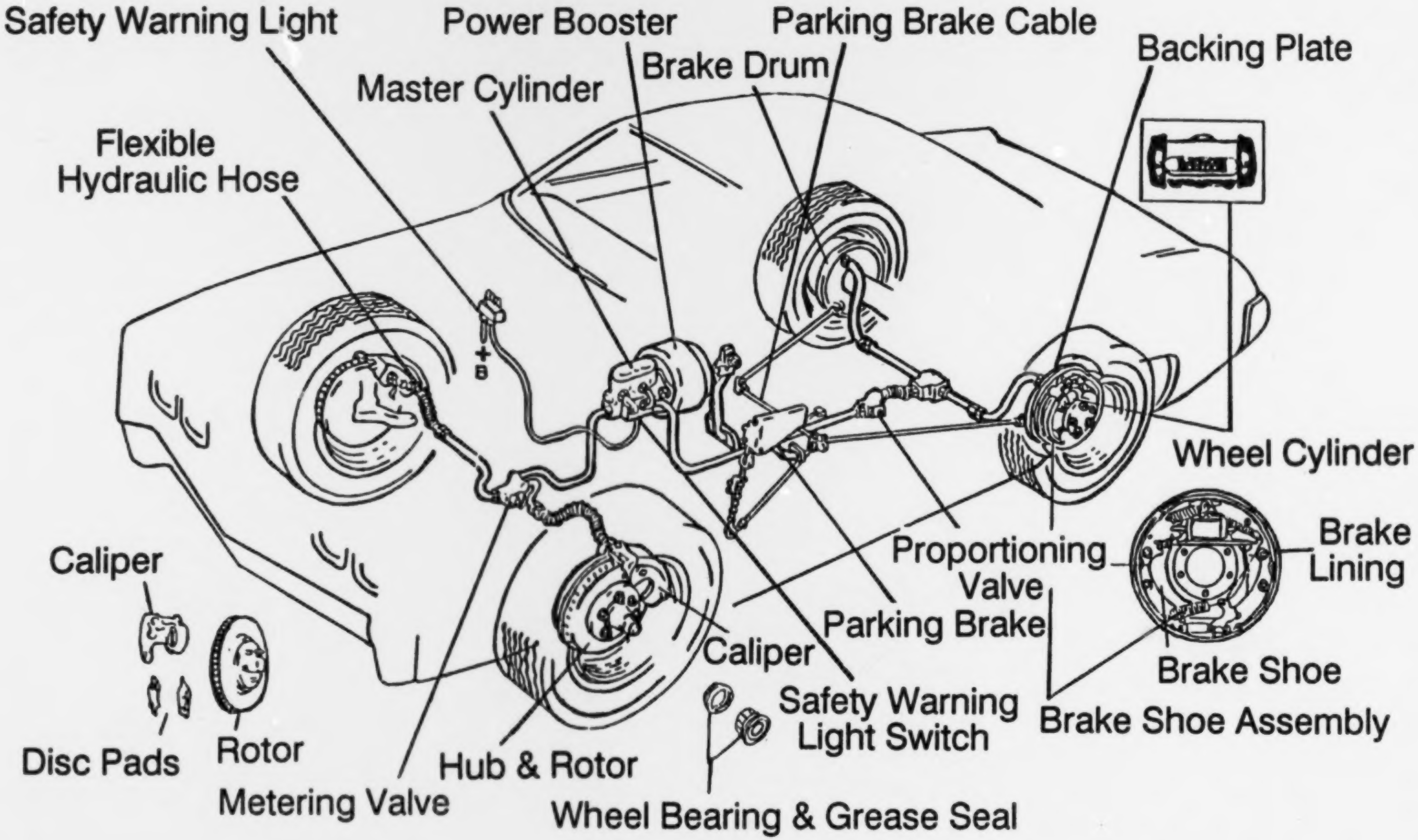
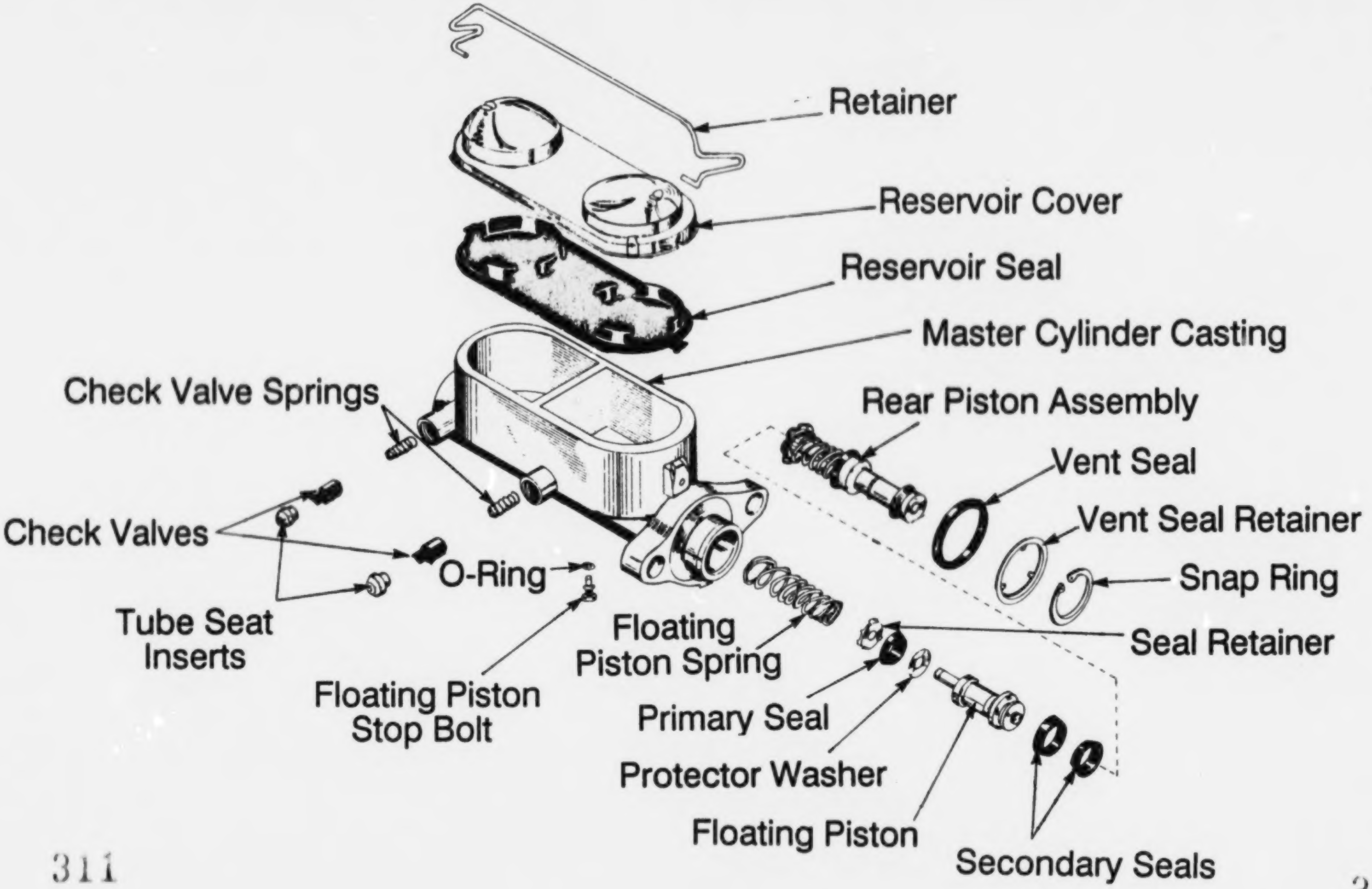
The Braking System

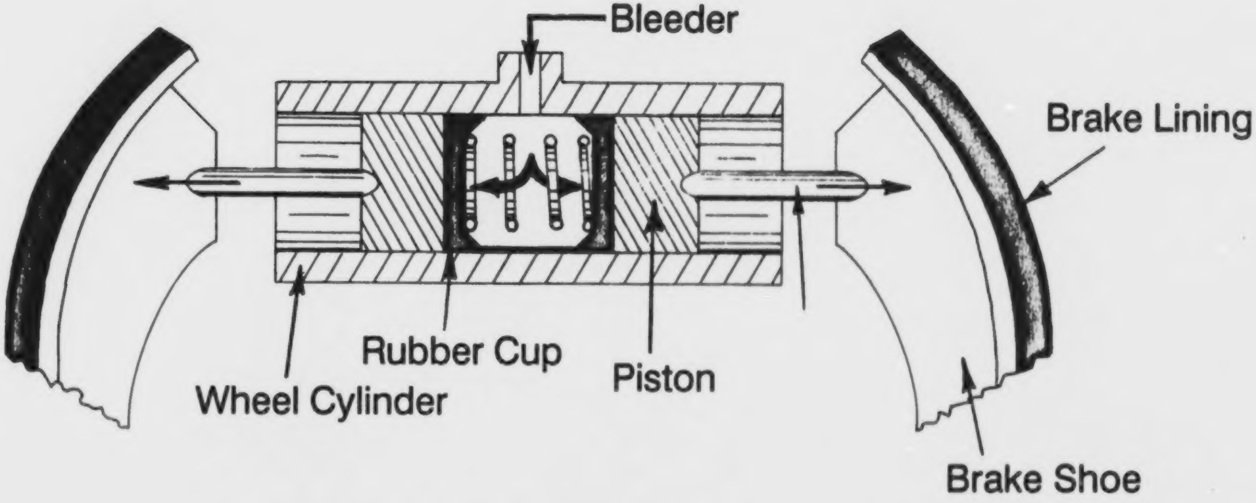

Safety Warning Light
Power Booster
Parking Brake Cable
Backing Plate
Brake Drum
Master Cylinder
Flexible Hydraulic Hose
+B
Wheel Cylinder
Brake Lining
Proportioning Valve
Caliper
Parking Brake
Caliper
Brake Shoe
Safety Warning Light Switch
Brake Shoe Assembly
Disc Pads
Rotor
Hub & Rotor
Metering Valve
Wheel Bearing & Grease Seal

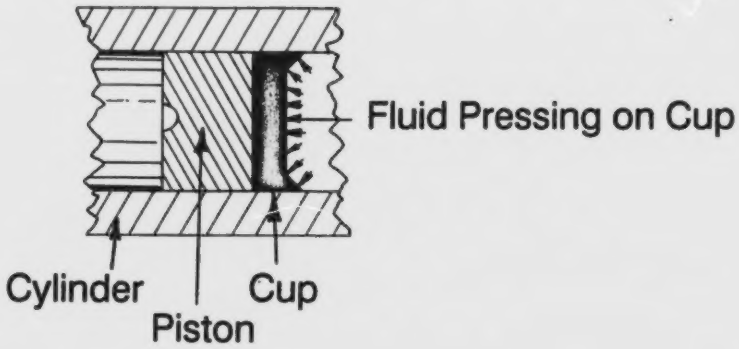
Double Piston Master Cylinder


Retainer
Reservoir Cover
Reservoir Seal
Master Cylinder Casting
Check Valve Springs
Rear Piston Assembly
Vent Seal
Vent Seal Retainer
Check Valves
Snap Ring
O-Ring
Tube Seat Inserts
Floating Piston Spring
Seal Retainer
Floating Piston Stop Bolt
Primary Seal
Protector Washer
Floating Piston
Secondary Seals

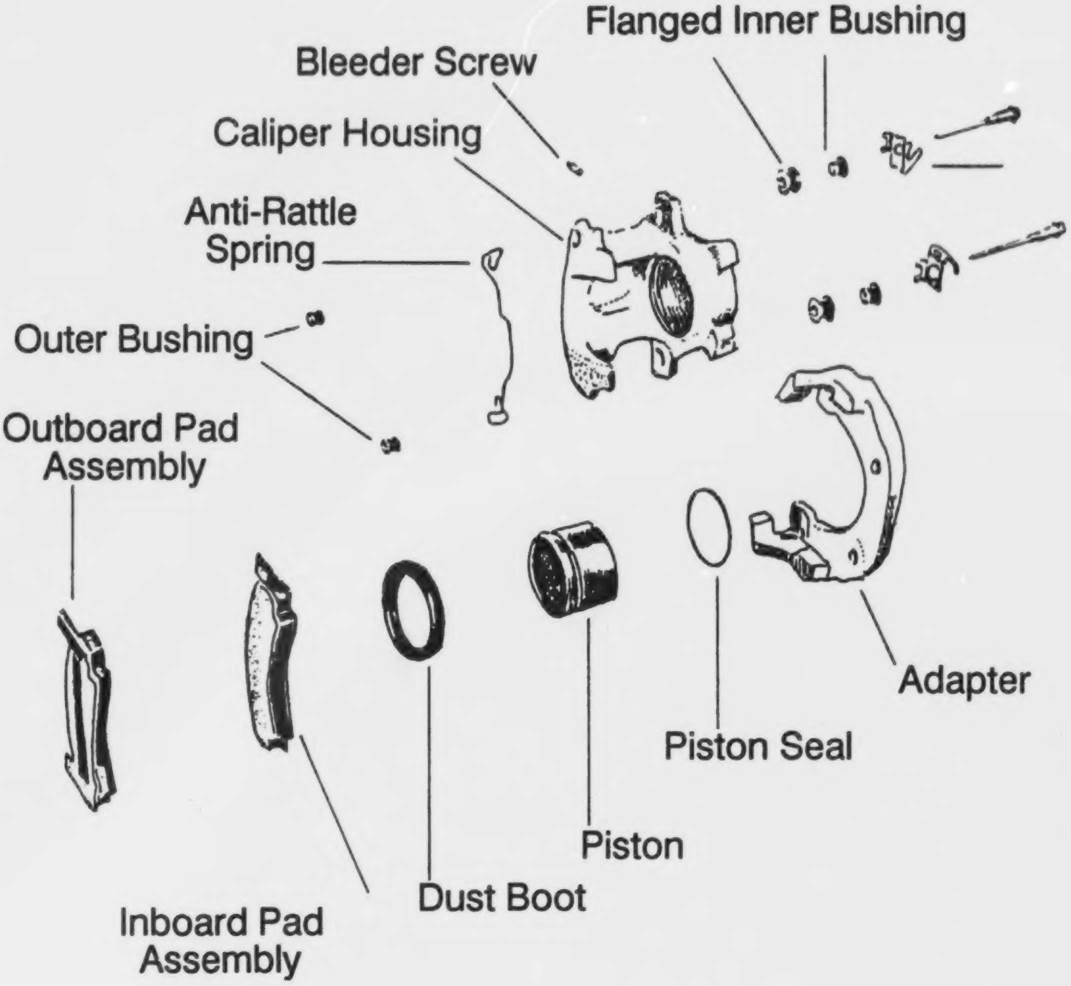
TM-4

Wheel Cylinder

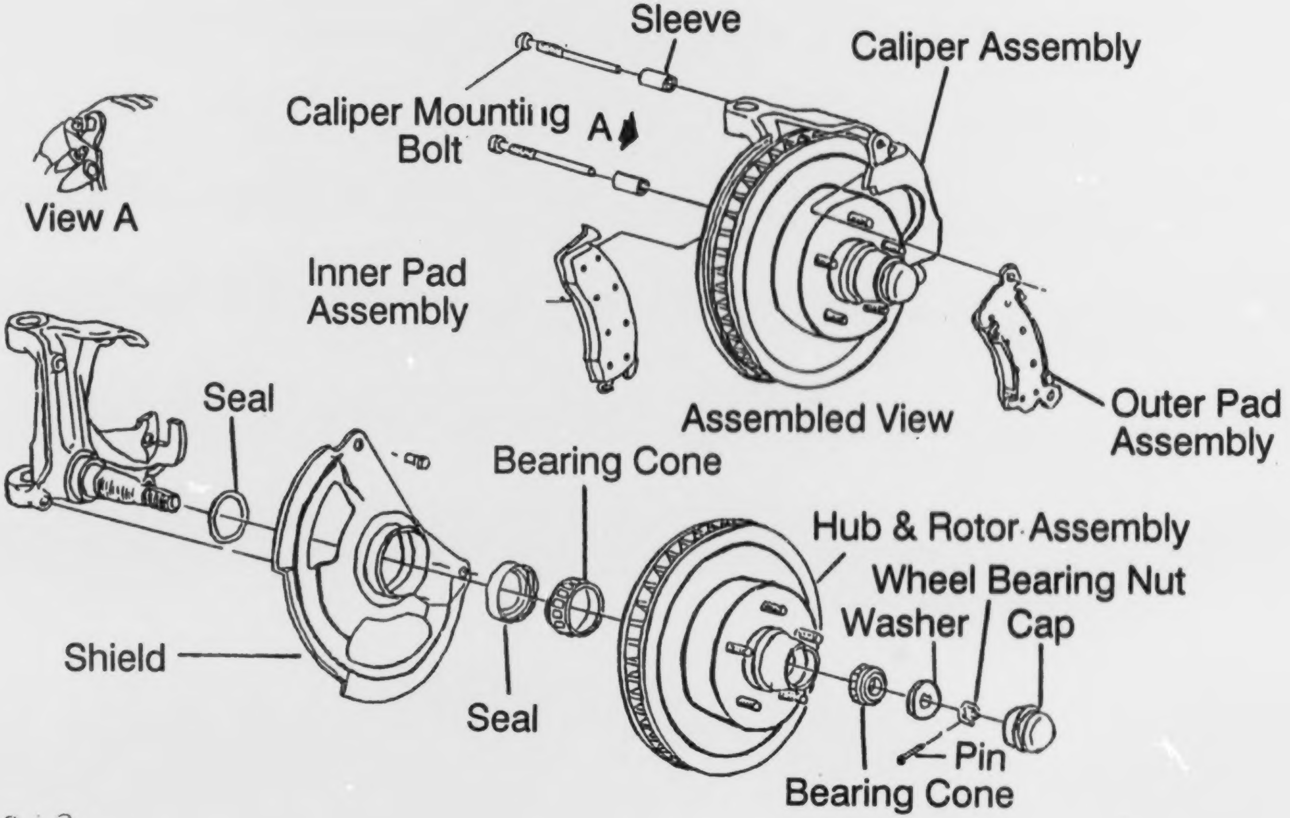

Bleeder
Brake Lining
Rubber Cup
Piston
Wheel Cylinder
Brake Shoe


Fluid Pressing on Cup
Cylinder
Cup
Piston

Disc-Brake Caliper

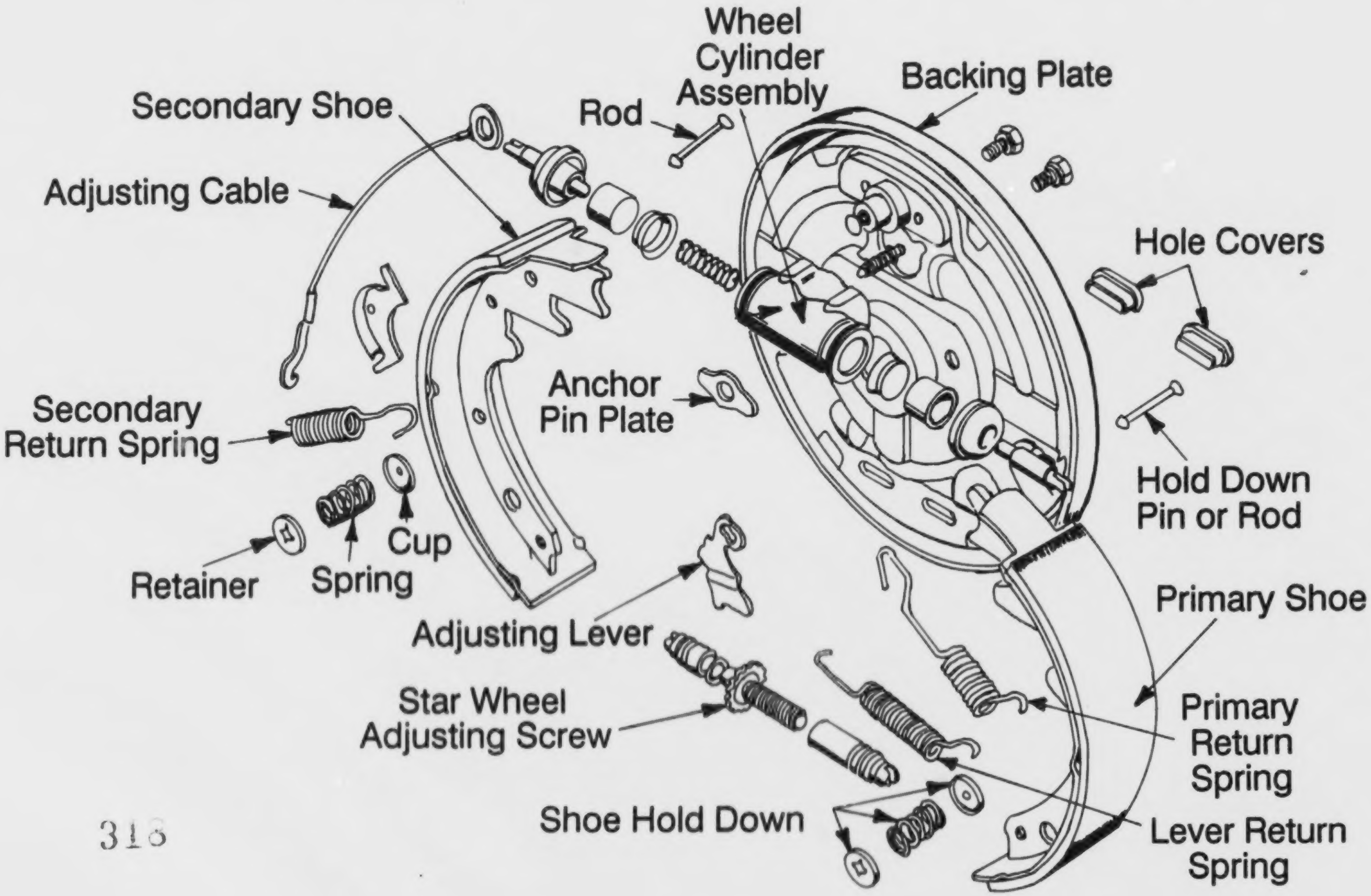

Flanged Inner Bushing
Bleeder Screw
Caliper Housing
Anti-Rattle Spring
Outer Bushing
Outboard Pad Assembly
Adapter
Piston Seal
Piston
Dust Boot
Inboard Pad Assembly

Disc Brake Assembly-Exploded


Sleeve
Caliper Assembly
Caliper Mounting Bolt
A
View A
Inner Pad Assembly
Assembled View
Outer Pad Assembly
Seal
Bearing Cone
Hub & Rotor Assembly
Wheel Bearing Nut
Washer
Cap
Shield
Seal
Pin
Bearing Cone

TM-7

Exploded View of Brake Assembly


Wheel Cylinder Assembly
Backing Plate
Secondary Shoe
Rod
Adjusting Cable
Hole Covers
Anchor Pin Plate
Secondary Return Spring
Hold Down Pin or Rod
Cup
Retainer
Spring
Primary Shoe
Adjusting Lever
Star Wheel Adjusting Screw
Primary Return Spring
Shoe Hold Down
Lever Return Spring

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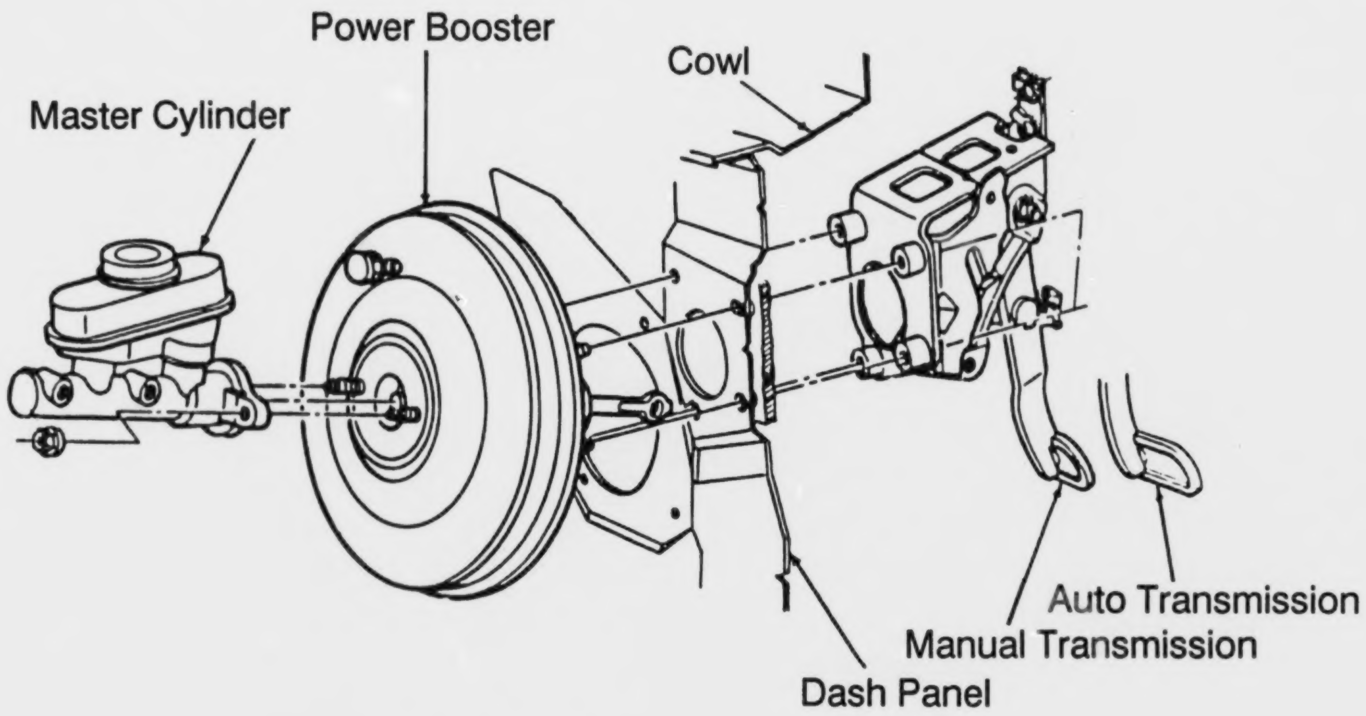
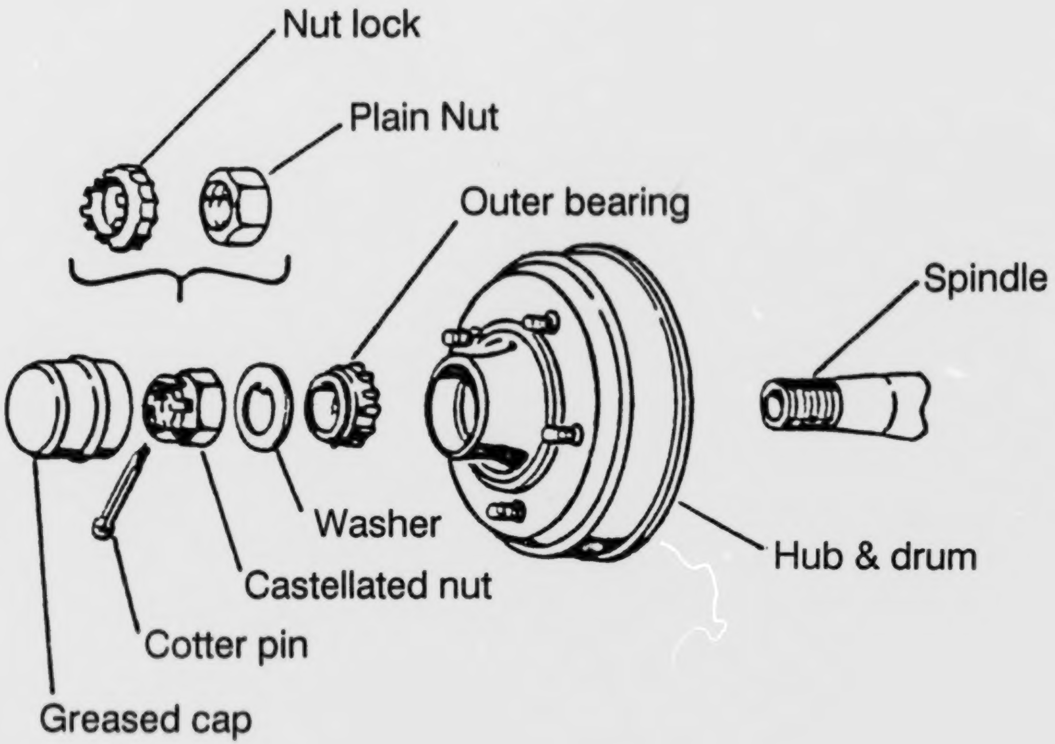
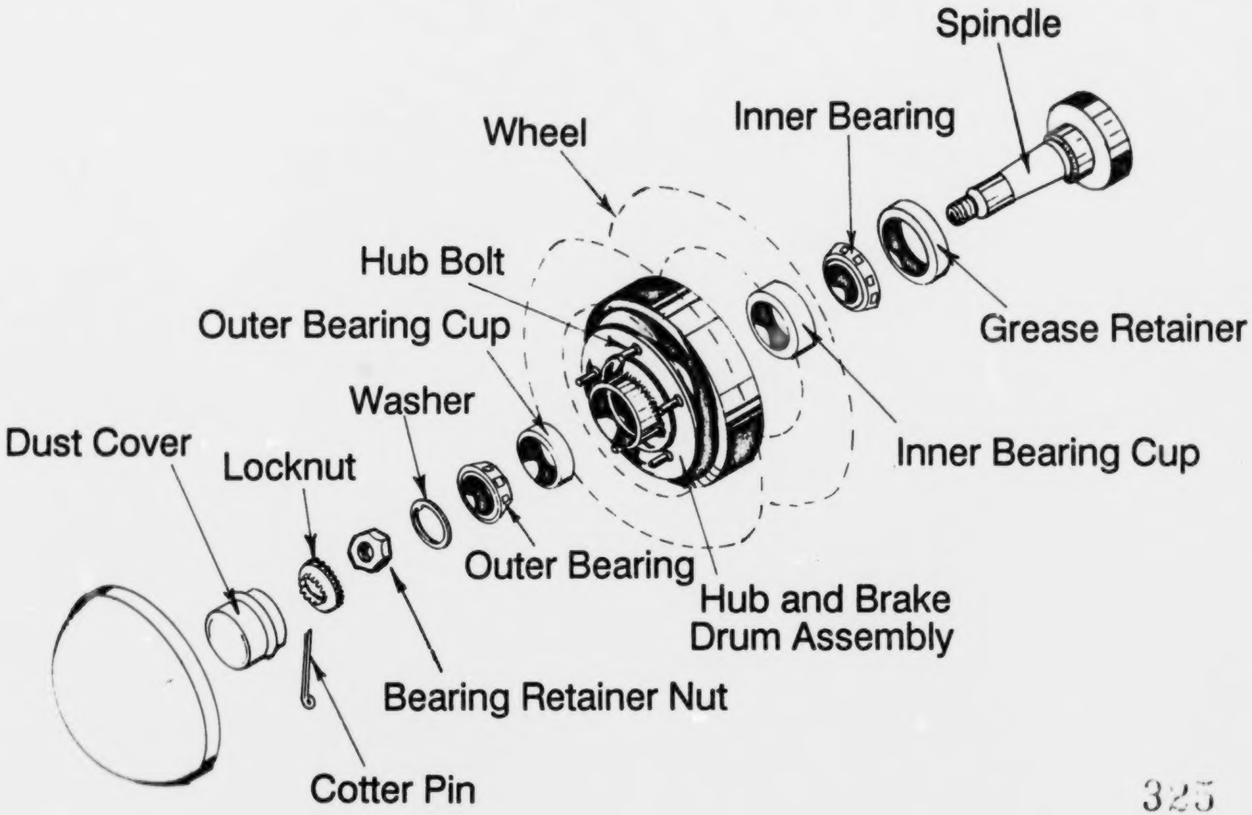
Master Cylinder with Power Booster


Power Booster
Cowl
Master Cylinder
Auto Transmission
Manual Transmission
Dash Panel

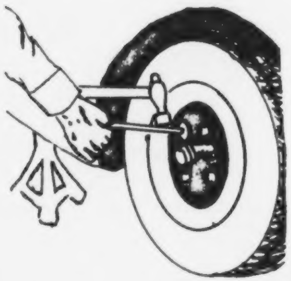
Typical Wheel Assembly


Nut lock
Plain Nut
Outer bearing
Spindle
Greased cap
Cotter pin
Castellated nut
Washer
Hub & drum

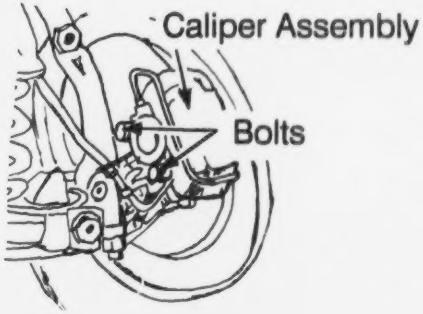
Wheel Bearing Assembly


Spindle
Inner Bearing
Wheel
Grease Retainer
Hub Bolt
Outer Bearing Cup
Washer
Inner Bearing Cup
Dust Cover
Locknut
Outer Bearing
Hub and Brake Drum Assembly
Bearing Retainer Nut
Cotter Pin

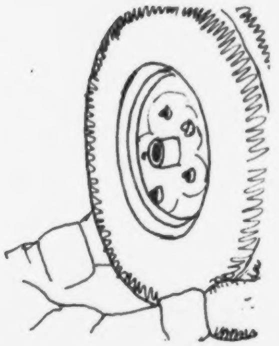
Cleaning, Inspecting, and Packing Wheel Bearing



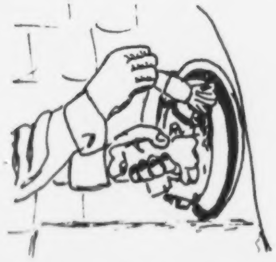
1 Remove Dust Cap



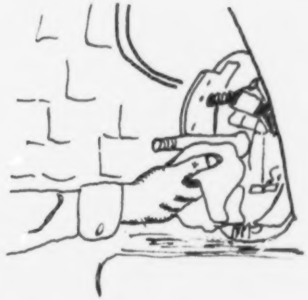
2 Remove Brake Caliper Where Used



3 Remove Cotter Pin, Adjusting Nut, & Pull Wheel

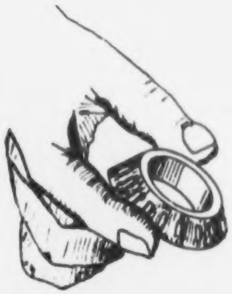


4 Cover Spindle & Clean Brake Assembly

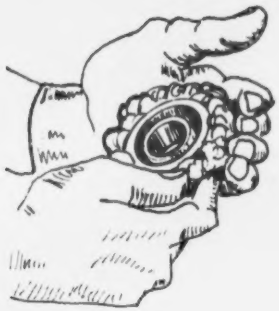


5 Clean, Inspect, & Lube Spindle

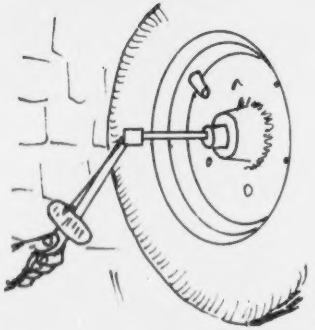
Cleaning, Inspecting, and Packing Wheel Bearing



6 Clean & Inspect
Wheel Bearings

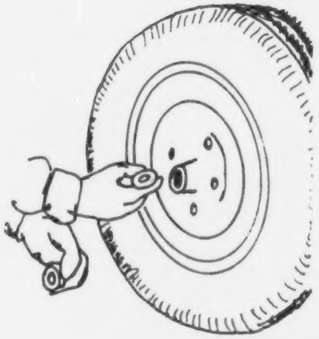


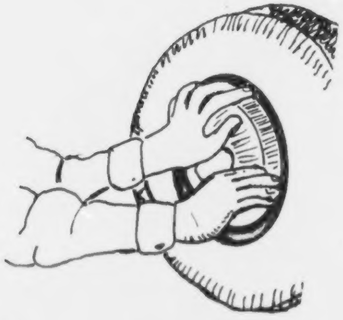
7 Pack Bearings



9 Adjust Bearings,
Install Cotter Pins
& Dust Cover

8 Lube Hub, Install Bearings,
& Grease Seal. Install Wheel,
Outer Bearing, Safety Washer,
& Adjusting Nut





10 Install Wheel Cover
or Hub Cap

II-10-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Brake and Bearing Systems

TOPIC: Brake and Bearing Systems

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the brake system.

2. Match the terms and definitions associated with the brake system.

_____a. The part of the hydraulic system in which pressure is generated

_____b. The part of the system that receives pressure from the master cylinder and applies it to brake shoes in the brake drum

_____c. The part of the brake system with an attached brake lining which creates friction when it comes into contact with the brake drum

_____d. A cast iron or aluminum housing, bolted to the wheel, that rotates around the brake shoes and gives a surface for the brake shoes to rub against

1. Wheel cylinder
2. Bleeding the brakes
3. Caliper
4. Brake fluid
5. Pads

_____e. A brake system which uses a steel disc with a caliper type of lining holder instead of the internal brake shoe type

_____f. A clamping device which houses the hydraulic cylinder and pads on the disc brake

_____g. A type of brake lining used with disc brakes

_____h. A rigid steel plate to which the brake shoes are attached

_____i. A special fluid designed for the hydraulic brake system

_____j. Removing the air from the hydraulic system

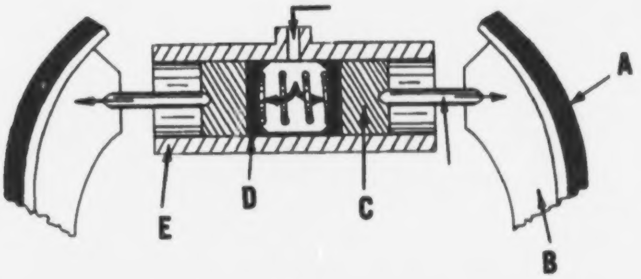
_____k. A reduction in braking force due to loss of friction between brake shoes and drum, caused by heat buildup

_____l. A device placed in a braking system to increase the pressure output and decrease the amount of effort required to operate the brakes

6. Brake-backing plate
7. Booster
8. Brake fade
9. Master cylinder
10. Brake drum
11. Disc brakes
12. Brake shoes

3. Identify the components of the wheel cylinder by placing each of the parts names listed below in the correct blank.

Wheel cylinder
Piston
Brake lining
Cup
Brake shoe

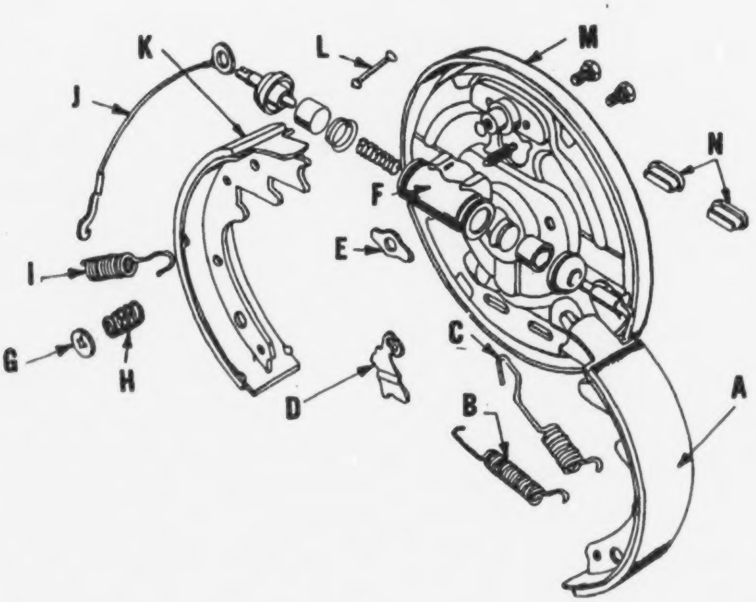


a. ______________________
b. ______________________
c. ______________________
d. ______________________
e. ______________________

4. Identify the components of the brake mechanism by placing each of the parts names listed below in the correct blank.

Primary shoe
Secondary shoe
Secondary return spring
Adjusting cable
Hold down pin
Hole covers
Retainer

Spring
Adjusting lever
Wheel cylinder assembly
Backing plate
Anchor pin plate
Primary return spring
Lever return spring



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

k. ______________________

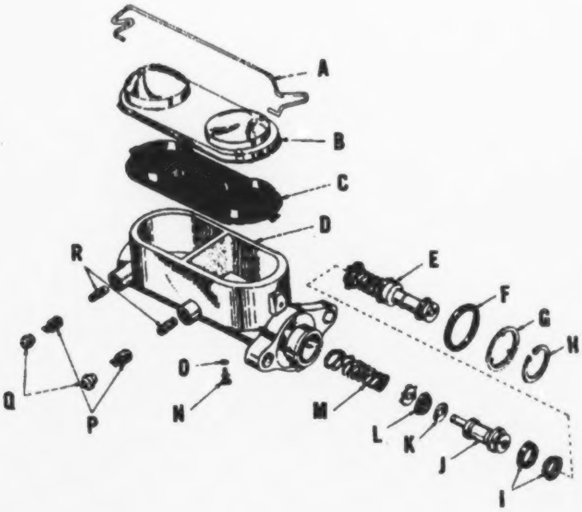
l. ______________________

m. ______________________

n. ______________________

5. Identify the components of the master cylinder by writing the name of each lettered part in the corresponding blank below.

Reservoir cover
Reservoir seal
Retainer
Master cylinder casting
Rear piston assembly
Vent seal
Vent seal retainer
Floating piston stop bolt
Check valves
Secondary seals
Floating piston
Protector washer
Primary seal
Snap ring
Floating piston spring
O-ring
Tube seat inserts
Check valve springs



a.________________________

b.________________________

c.________________________

d.________________________

e.________________________

f.________________________

g.________________________

h.________________________

i.________________________

j.________________________

k.________________________

l.________________________

m.________________________

n.________________________

o.________________________

p.________________________

q.________________________

r.________________________

6. Point out the cause of each of the brake system malfunctions by placing the correct number by each malfunction.
Note: *You may place several numbers by each letter.*

_____a. Low pedal

_____b. A bearing that has been lubricated at the factory and sealed

_____c. Spongy pedal

_____d. Excess pedal pressure required to stop car

_____e. Inner and outer ring on which ball bearings run

_____f. Pulsating brake pedal

_____g. Brakes fade

_____h. Brakes drag when properly adjusted

_____i. A bearing with tapered steel rollers between an inner and outer race

_____j. One wheel drags

_____k. Rear brakes drag

_____l. Car pulls to one side

_____m. An inner and outer race separated by steel balls

1. Grease on several linings
2. Drums out of round
3. Pedal not returning to stop
4. A broken retracting spring
5. Improper parking brake adjustment
6. Air trapped in system
7. Disc warped
8. Low fluid level
9. Incorrrect lining on one side
10. Linings not properly contracting
11. A frozen master cylinder
12. Drums worn too thin
13. Tapered roller bearing
14. Ball bearing
15. Race
16. Sealed bearing

II-10-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Brake and Wheel Bearing Systems

TOPIC: Brake System Inspection

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to inspect a brake system correctly.

TOOLS AND EQUIPMENT:
Tools for wheel and tire removal
Tools for brake and drum removal
Drop light
Inspection mirror
Appropriate shop manual
Clean shop towels
Fender and seat covers

GENERAL INSTRUCTIONS: Follow procedures to inspect a brake system properly.

PROCEDURES AND/OR TASKS:

1. Check manufacturer's shop manual for specifications.

2. Place vehicle on stands.

3. Install covers for fenders and seats.
   Note: *Use check list to indicate condition of components.*

4. Check fluid level in master cylinder and look for signs of external leakage.

5. With ignition switch on, step on brake pedal, test for low pedal, spongy feel, hard pedal, or no pedal (pedal goes to floor). Check the brake warning light.

6. Check dust boot on master cylinder for signs of fluid leakage.

7. Remove wheels and tires and place out of walkway.

8. Check steel lines and fittings for damage or leakage.

9. Check rubber flex hoses for cracking, bulging or signs of leaking.

10. Check metering, proportioning and pressure differential valves for leaks and secure if needed.

11. Remove brake drums.
    Note: *If vehicle has disc brakes, do not remove the rotors.*

12. Check wheel cylinders for brake fluid leaks by pulling the dust boots loose at each end. Also check for corrosion.

13. Disc brake caliper cylinders and boots can be checked for leakage and damage by using a small inspection mirror and drop light.
    Note: *Any leaks, wear or damage should be reported to the instructor.*

14. Install brake drums and wheels.

15. Lower vehicle from safety stands.

16. Remove fender and seat covers.

17. Test vehicle and check for proper operation.

18. Have instructor check work.

19. Replace tools and equipment.

20. Clean work area.

II-10-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Brake and Bearing System

TOPIC: Service the Master Cylinder and Power Booster

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to service a master cylinder and a power booster correctly.

TOOLS AND EQUIPMENT:

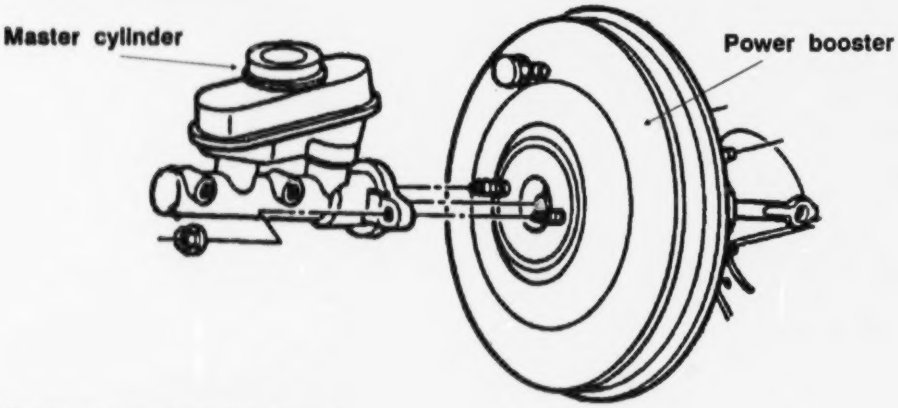
Shop towel
Hose clamp pliers
Common screwdriver
Open-end wrench
Brake fluid, proper type
Fender cover

GENERAL INSTRUCTIONS: Follow procedures to service the master cylinder and the power booster properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Open car hood and put on fender cover.
2. Clean the area around master cylinder cover.

3. Remove the master cylinder cover.
   CAUTION: Take necessary precautions to keep all dirt out of the cylinder.
   Note: *Do not spill fluid*



4. Clean any vent holes in cap.
   Note: *Later-model vehicles have a diaphragm type of cover.*

5. Fill the master cylinder fluid reservoir.

6. Replace the cover.

7. Check the lines to the power booster for leaks if the vehicle is equipped with power brakes.

8. Clean the filters at the air inlet.

9. Have instructor check work.

10. Close the car hood.

11. Replace tools and equipment.

12. Clean work area.

II-10-JS-3

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Brake and Bearing System

TOPIC: Replace Brake Shoes

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to replace brake shoes correctly.

TOOLS AND EQUIPMENT:

Hydraulic floor jack
Four jack stands
Lug wrench
Large common screwdriver
Rubber mallet
Box-end wrench set
Brake-bleeder wrench
Brake-adjusting tool
Brake-spring pliers
Brake fluid
Fender cover
Light gauge wire, 18-in. long

GENERAL INSTRUCTIONS: Follow procedures to replace brake shoes properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise the car enough to place jack stands.
2. Place jack stands in a secure position.
3. Remove the hub caps.
4. Remove the hub dust cover.

5. Remove the lock nut cotter pin.

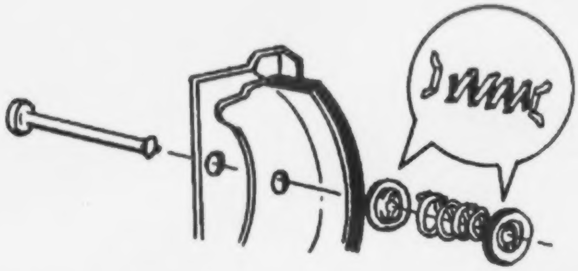
6. Remove the lock nut.

7. Remove the wheel and drum assembly.
   CAUTION: Use caution in removing bearings and wheel assembly so the spindle will not be damaged.

8. Remove the brake shoe retracting springs with the spring pliers.

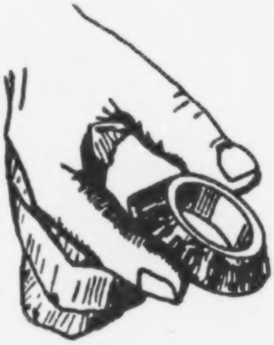
9. Remove the adjusting screw spring.

10. Remove the brake shoe hold-down springs and clips.



11. Remove the anchor pin plate.

12. Remove the brake shoes.



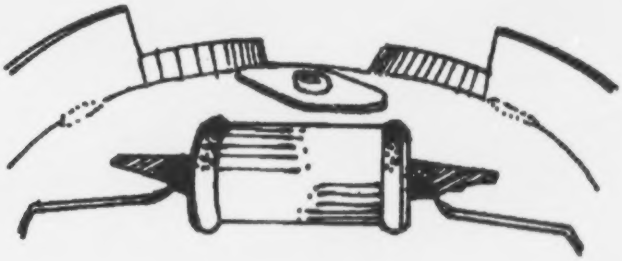
13. Place a wire around brake cylinder push rods to hold the rods in place.
    Note: *If the cylinder is to be rebuilt, see Job Sheet #4, section 10 for the correct procedure.*

14. Clean the backing plate and brake parts.

15. Clean and repair the brake drum, if required.

16. Install new brake shoes.
    Note: *The wide shoes go to the front wheels and the narrow shoes to the rear wheels, with the shorter shoes on the front side of each wheel.*

17. Install the anchor-pin plate.



18. Install the brake shoe hold-down springs and clamps.

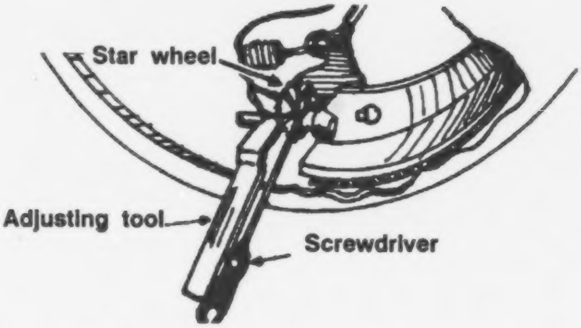
19. Install the adjusting screw spring and adjusting screw in closed position.

20. Install the brake-shoe retracting spring.

21. Pry out the old grease seal, and install a new one. Remount the wheel and drum assembly on the spindle.
    CAUTION: Protect the spindle and bearings.

22. Install the lock nut, lock nut cotter pin, hub dust cover, and hub cap.
    Note: *Refer to Job Sheet #12 in Section 10, for proper bearing adjustment.*

23. Adjust brakes by opening the adjusting screw with the brake-adjusting tool.
    Note: *The adjuster lever might have to be held back with a screwdriver.*



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24. Adjust the shoes until they keep the wheel from rotating, and then back the adjusting screw off until the brake shoes drag only slightly.

25. Remove the jack stands.

26. Lower the car to the floor.

27. Bleed the brakes and refill the master cylinder with fluid.
Note: *Refer to Job Sheet #4 for bleeding instructions.*

28. Test the car for poper braking, under the instructor's supervision.

29. Clean work area

JOB SHEET

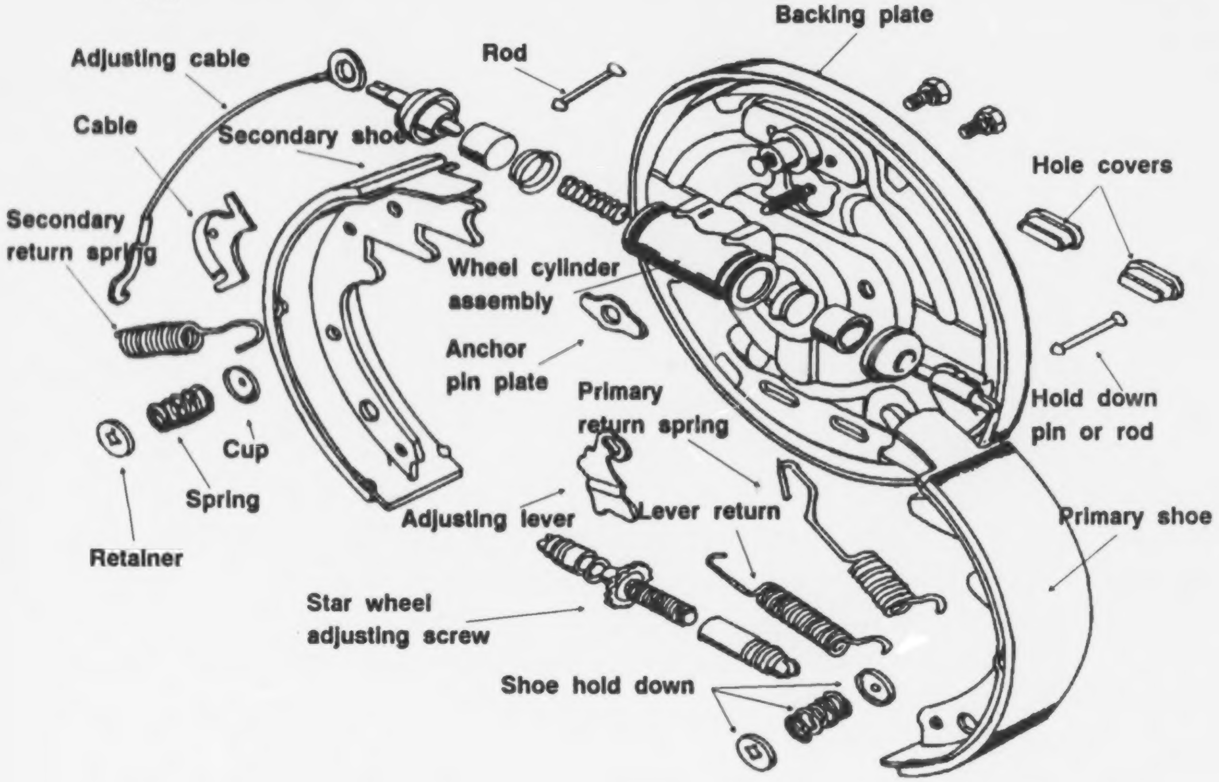
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT:	Brake and Bearing System
TOPIC:	Rebuild a Wheel Cylinder
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(D)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to rebuild a wheel cylinder correctly.
TOOLS AND EQUIPMENT:	Cylinder hone Shop rags Wheel-cylinder rebuilding kit Brake fluid Fender cover Portable electric drill
GENERAL INSTRUCTIONS:	Follow procedures to rebuild the wheel cylinder properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

1. Raise the hood and put on fender cover.

2. Remove all wheel and brake parts following the procedures outlined in Job Sheet #2.



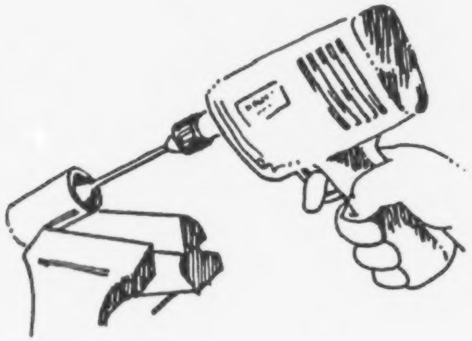
Backing plate
Adjusting cable
Rod
Cable
Secondary shoe
Hole covers
Secondary return spring
Wheel cylinder assembly
Anchor pin plate
Primary return spring
Hold down pin or rod
Cup
Spring
Retainer
Adjusting lever
Lever return
Primary shoe
Star wheel adjusting screw
Shoe hold down

3. Remove push rods.

4. Remove cylinder from the backing plate.

5. Remove boots and cylinder assembly.

6. Clean cylinder with solvent, then hone the cylinder, using a small amount of solvent as a lubricant.



7. Clean the cylinder thoroughly and blow dry.
8. Lubricate all internal parts with brake fluid, and wipe the inside bore of the cylinder.
9. Install new parts in wheel cylinder.
10. Install wheel cylinder on backing plate.
11. Replace all wheel and brake parts following the procedures outlined in previous Job Sheets.
12. Have instructor check work before reinstalling drum and wheel.
13. Test the car for proper braking under the instructor's supervision.
14. Replace tools and equipment.
15. Clean work area.

II-10-JS-5

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ____________________

UNIT: Brake and Bearing System

TOPIC: Bleeding the Hydraulic System

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(1)(B), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to bleed a hydraulic system correctly.

TOOLS AND EQUIPMENT:

Sufficient hand tools for removing master cylinder reservoir covers
3/8 or 1/4-in. six-point box-end wrench for opening bleeder screws
Fender covers, drop light, and creeper
Pressure tank brake bleeding equipment
Brake fluid
Clean glass container and bleeder hose
Bulb type syringe for filling the reservoir with brake fluid
Clean shop towels
Appropriate shop service manual
A helper mechanic

GENERAL INSTRUCTIONS: Follow procedures to bleed the hydraulic system, manually, and with pressure properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

CAUTION! Keep brake fluid out of your eyes. If some gets in, immediately flush thoroughly with water.

1. Manually bleeding the brake hydraulic system:

a. Place fender cover on vehicle left fender and remove master cylinder reservoir cover and gasket.

Note: *Hydraulic brake fluid will damage automotive finishes and other painted surfaces. Use extreme care when servicing brake systems.*

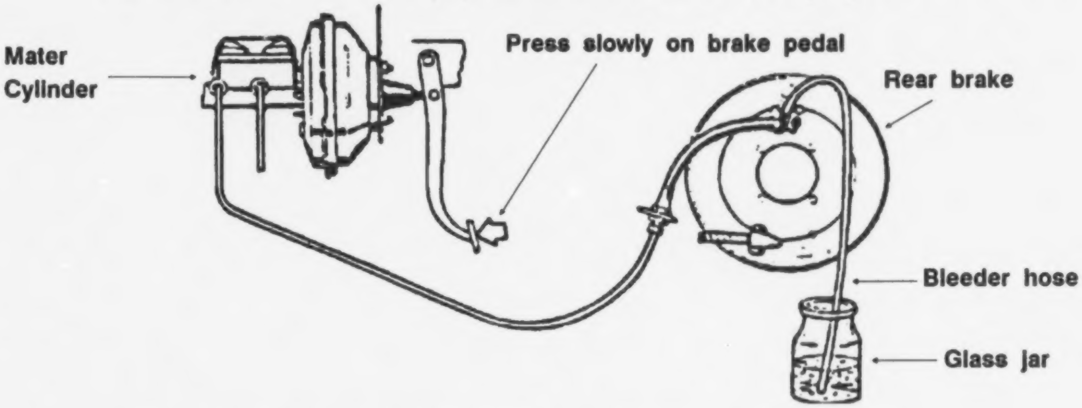
b. Fill the master cylinder with clean fresh brake fluid and install gasket and cover.

c. Place vehicle on safety stands to allow access to wheel cylinder bleeder screws.

d. Attach the bleeder hose to the bleeder screw at the right rear wheel.

Note: *Always bleed the cylinder farthest from the master cylinder first, then work your way forward toward the closest one.*

e. Place the loose end of the bleeder hose in the glass container, partially filled with brake fluid. A clean pop bottle will work for this purpose.



Note: *The end of the bleeder hose must be completely submerged.*

f. Open the bleeder screw approximately 3/4 of a turn.

Note: *Use only a six-point wrench on the bleeder screw to prevent damage to the screw.*

g. Have the helper depress the brake pedal slowly to the end of its travel and hold it down.

h. Close the bleeder screw.

i. The helper can now allow the pedal to return slowly to the fully released position.

Note: *This step should be accomplished with the bleeder screw only in the closed position.*

j. Repeat steps 6, 7, 8, and 9 until a solid stream of brake fluid flows from the end of the bleeder hose into the glass container.

Note: *The cylinder is bled when the fluid flowing into the container has no indication of air bubbles.*

k. Tighten the bleeder screw securely and remove the bleeder hose.

l. Refill the master cylinder with brake fluid.

m. Repeat the bleeding operation on the remaining cylinders.

n. Upon completion of the bleeding operation, refill the master cylinder reservoir with clean fresh brake fluid.

Note: *Since one of the characteristics of brake fluid is to suspend water particles, fluid bled from brake systems is normally contaminated and should be discarded.*

o. Remove vehicle from safety stands and check for a solid brake pedal of recommended height.

2. Pressure bleeding the brake hydraulic system:

a Prepare the vehicle the same as for manual brake bleeding.

CAUTION! Use care to prevent brake fluid from damaging the automobile finish.

b. Select the master cylinder adapter for the vehicle being bled.

c. Fill the master cylinder with clean fresh brake fluid and install the master cylinder adapter.

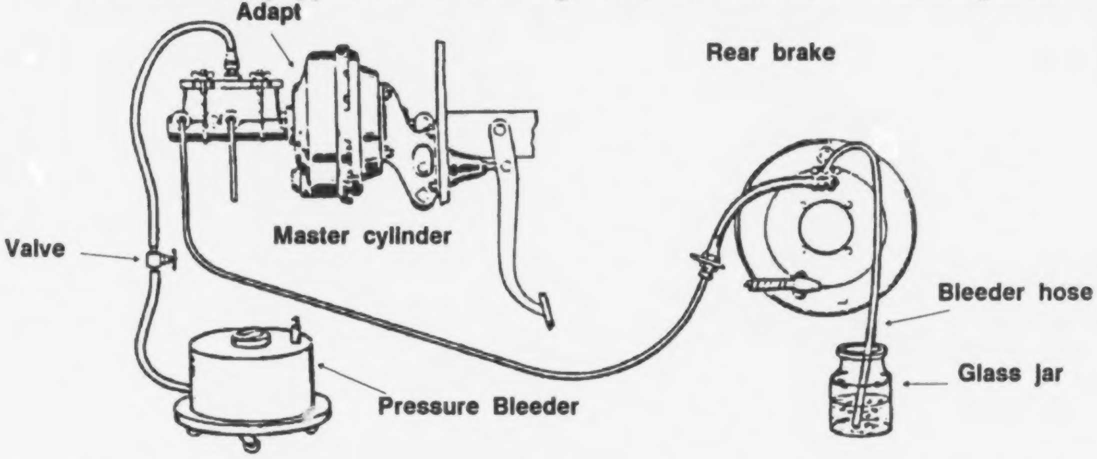
d. Check the bleeder tank. It should be at least ⅓ full of brake fluid and show from 25 to 35 PSI.

Note: *Follow the equipment manufacturer's specifications and directions for bleeder operations.*

e. Connect the bleeder tank hose to the master cylinder adapter.

Note: *Check hose, connections, and adapter for leaks.*

f. If vehicle is equipped with a metering valve, the valve stem must be pushed in or pulled out, depending upon the type.



g. From this point, the sequence is the same as manual bleeding. Using the hose and glass container, bleed the right rear cylinder first, then work your way forward, finishing up with the left front.

Note: *If vehicle master cylinder is equipped with a bleeder screw, always bleed the master cylinder before bleeding any wheel cylinder.*

h. Remove bleeder tank hose from the adapter, the adapter from the master cylinder, and check fluid level in the master cylinder.
i. Install master cylinder reservoir cover and gasket.
j. Check brake pedal height, and for a solid feel.

   Note: *Do not attempt to drive vehicle until a solid pedal is obtained.*

k. Test drive vehicle and check for brake operation.

3. Have instructor check work.

4. Replace tools and equipment.

5. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ **DATE** ____________________

UNIT:	Brake and Bearing System
TOPIC:	Disc Brake Pad Replacement
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B), (ddd)(1)(D)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to remove and replace disc brake pads correctly.
TOOLS AND EQUIPMENT:	Jack, safety stands, and fender covers Tire and wheel removal tools Necessary hand tools for caliper removal Appropriate shop manual Hand suction pump and container for brake fluid Mechanics stool 8-in. "C" Clamp
GENERAL INSTRUCTIONS:	Follow procedures to replace disc pads properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

Note: *Check shop manuals for steps unique to the vehicle.*

1. Caliper removal:
   a. Siphon about 2/3 of the brake fluid from master cylinder reservoir that supplies the disc brakes.

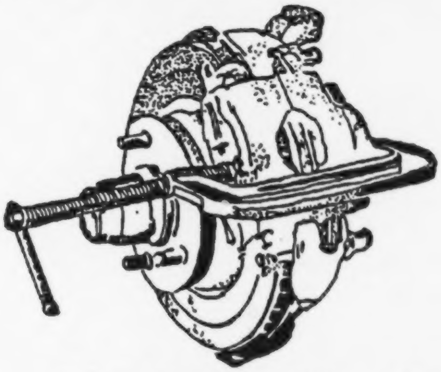
      CAUTION: Do not drain the reservoir.

   b. Raise the vehicle and place the safety stands under the frame of the vehicle.

c. Remove the tire and wheel assembly.

Note: *Do not attempt to remove the rotor with the wheel and tire assembly.*

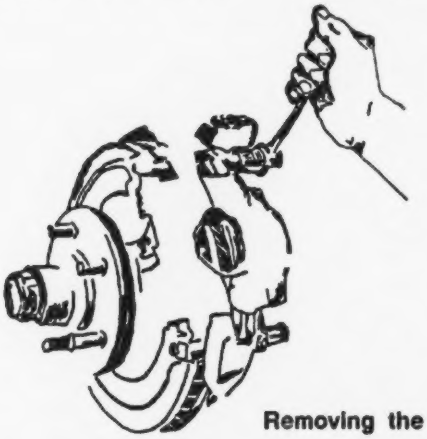
d. Position the "C" Clamp over the caliper with the fixed side of the clamp against the back of the caliper and the screw side against the back of the outer brake pad. Tighten the clamp to force the piston into the cylinder. This will allow the pads to back away from the rotor permitting removal of the caliper.



Forcing Piston Into Cylinder Bore

e. Remove the "C" Clamp.

f. Remove the caliper guide pins that hold the caliper to the support bracket.



Removing the Caliper Guide Pins

g. Lift the caliper off the rotor, being careful not to stretch the brake hose. Place the caliper on the suspension arm so that the bottom faces up, or suspend the caliper with wire from a convenient place.

h. Lift the inner and outer pads out of the caliper.

2. Inspection of parts:

a. Check the caliper piston for leaks, the boot for damage, and the caliper for cracks. If any defects are noted, the caliper must be removed and rebuilt, or replaced.

b. If no defects are noted, clean the caliper.

CAUTION: Do not use compressed air. You might unseat the boot from the piston.

c. Inspect the rotor for signs of wear or defects. If defects are noted, the rotor must be removed for service.

3. Brake pad installation:
   a. Force the piston into the bore until it bottoms. This will allow sufficient room for the new brake linings to straddle the rotor.
   b. Install the support spring, or clip, as the type required. Some types must be installed in the piston. *See Shop Manual.*
   c. Place the inner pad into the caliper, with the ears of the pad toward the inner ears of the caliper, and the spring clip resting on the inside diameters of the piston.
   d. Position the outer brake pad in the caliper with the lining facing the piston. Place the two ears of the pad over the outer ears of the caliper. The bottom flange of the pad fits into the cutout section of the caliper.
   e. Position the caliper over the rotor and slide it down until the caliper pin-bolts holes are aligned.

      Note: *Be careful that the brake hose is not kinked or twisted.*
   f. Clean the guide pins and lubricate them lightly with assembly fluid.

4. Install the caliper. Torque the guide pin bolts to recommended specifications.

5. Refill master cylinder; pump the brake pedals several times to seat the pads to the rotor. Recheck fluid level.
   Note: *If firm pedal is not obtained, bleed the system.*

6. Install the wheel and tire assembly.

7. Double-check all steps for safety.

8. Have instructor check work.

9. Test drive the vehicle, and check for proper operation of the brake system.

10 Replace tools and equipment.

11. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ________________________________ DATE ____________________

UNIT: Brake and Bearing System

TOPIC: Service the Disc Rotor and Pads

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to service the rotor and pads correctly.

TOOLS AND EQUIPMENT:

- Fender cover
- Hydraulic floor jack
- Pliers
- C-clamp
- Two jack stands
- Shop rag
- Micrometer
- Dial indicator

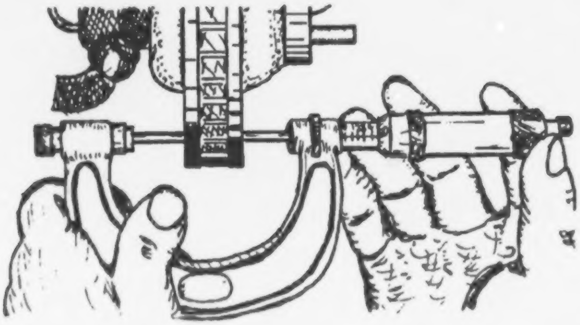
GENERAL INSTRUCTIONS: Follow procedures to service the disc and pads properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Remove the caliper from the spindle.
   Note: *If necessary refer back to the Job Sheet #6 for this procedure.*

2. Check for leakage around the piston seal. If leakage is present, notify instructor, and refer to Job Sheet #8.

3. Check the disc thickness with a micrometer.



4. Check several locations around the disc.

5. Check the disc for cracks or roughness.

6. Mount the dial indicator in a position to check the disc for warpage.

7. Turn the disc and check the disc for warpage.
   Note: *The disc should be replaced if the dial indicator shows movement of more than .003 of an inch.*

8. Remove the disc from wheel hub and have it turned on a lathe if necessary.
   Note: *It is a good idea to turn the rotors at every pad change. This not only corrects any warpage or runout, but also assures that the new pads have a smooth and true surface to work against.*
   Semi Metallic Pads: *If this type of pad is being installed, the rotor must be turned. An omni directional finish is then applied. Run a scotch brite abrasive disc in an air drill against the rotor as it turns on the lathe. This type of finish is necessary to burnish and fully seat metallic pads. If this procedure isn't followed, the pads will run hot, rotor damage and warpage will occur, and pad life will be greatly reduced.*

9. Replace the disc if removed.

10. Install the caliper and pads.

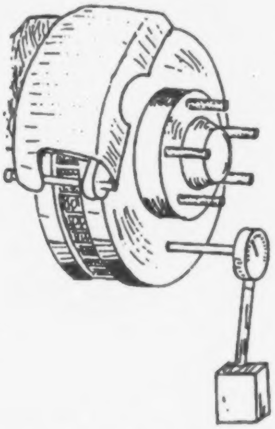
11. Replace the hydraulic hose.

12. Install the wheel.

13. Remove the jack stands.

14. Lower the car to the floor.

15. Replace the brake fluid and close the cover.



16. Bleed the brakes. If necessary, refer to Job Sheet #5.

17. Have instructor check work.

25. Close the hood.

25. Replace tools and equipment.

26. Clean work area.

II-10-JS-8

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Brake and Bearing System

TOPIC: Reconditioning a Disc Brake Caliper

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to recondition a disc brake caliper correctly.

TOOLS AND EQUIPMENT:

Appropriate tools for caliper removal
Appropriate tools for wheel and tire removal
Brake fluid and denatured alcohol
Compressed air, hose and nozzle
Clean shop towels and a flat metal pan
6-in. "C" Clamp
Appropriate shop manual

GENERAL INSTRUCTIONS: Follow procedures to service the caliper and disc properly.

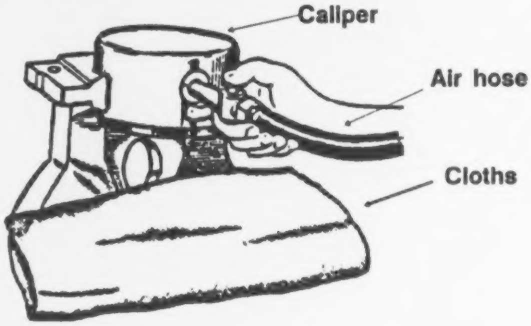
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

CAUTION: Keep brake fluid out of your eyes. If some gets in, immediately flush thoroughly with water.

1. Caliper removal and disassembly:
   a. Disconnect brake hose from caliper inlet.
   Note: *Plug inlet and brake hose to prevent dirt from entering system.*
   b. Remove the caliper and remove pads and plates from caliper as outlined in the shop manual.

c. Open the bleeder screw, remove the plug from the inlet, and drain the brake fluid from the caliper. **Note:** *Use the flat metal pan for assembly because the brake fluid may damage painted or finished surfaces.*

d. Position the caliper as shown in figure.
WARNING! Apply air pressure gradually, and be sure there are enough cloths to catch the piston when it comes out of the cylinder bore. Personal injury may result if piston is "popped" out of cylinder bore! Cylinder must be pointed away from you.



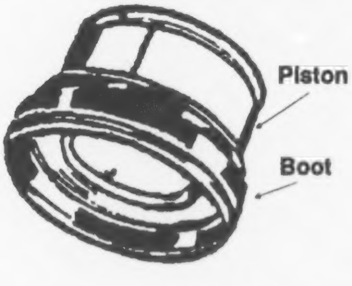
e. Apply air pressure gradually to caliper inlet to force piston out of cylinder bore.
Note: *If piston is seized and does not come out readily, release air pressure, and tap on end of piston with soft hammer. Then reapply air pressure.*

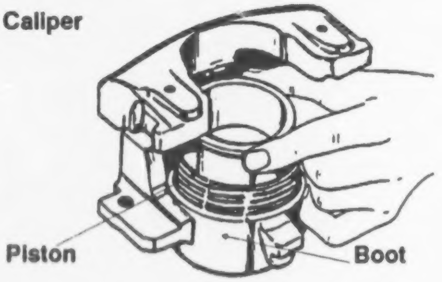
2. Cleaning and inspection:
   a. Remove any rust or corrosion from machined surface of caliper housing and anchor plate.

      Note: *Fine sandpaper may be used for this purpose.*
   b. Clean the caliper and piston in clean alcohol. Blow the parts dry with compressed air.
   c. Check caliper cylinder bore and piston for damage. Crocus cloth may be used to remove minor defects.
   d. Check caliper housing and anchor plate for damage. Replace any parts that are damaged or badly worn.

3. Reassembly and installation:
   a. Lubricate the caliper cylinder bore and the seal with clean brake fluid and install the seal into the groove of the cylinder bore.

      Note: *Be sure seal is fully seated and not twisted.*
   b. Lubricate the piston with brake fluid and insert it through the boot so that the boot is around the bottom (closed end) of the piston as shown in figure.





c. Lubricate the bead of the boot with clean brake fluid. Hold the piston and boot directly above the caliper cylinder bore, and use their fingers to work bead of boot into the groove near the top of the bore.

d. Press straight in on the piston until it bottoms in the cylinder.

Note: *Be sure that the boot is fully seated in the caliper and on the piston.*

e. Install the caliper as outlined in the appropriate shop manual.

f. Connect the brake hose to the caliper inlet.

Note: *Take care to prevent cross threading the connecting bolt, and be sure to check for correct installation of copper seal washers.*

4. Bleeding and checking operation:
   a. Fill the master cylinder with clean high-quality brake fluid and bleed according to the shop manual procedure.
   b. Check for leaks under maximum pressure.

   WARNING: Do not move the vehicle until a firm brake pedal is obtained.

   c. Test drive vehicle and check for proper brake operation.

5. Have instructor check work.

6. Replace tools and equipment.

7. Clean work area.

JOB SHEET

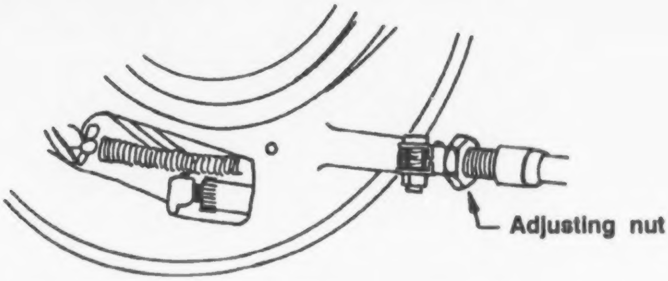
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT:	Brake and Bearing System
TOPIC:	Adjusting Park Brake
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to adjust the park brake correctly.
TOOLS AND EQUIPMENT:	Hydraulic floor jack Two jack stands Open-end wrenches
GENERAL INSTRUCTIONS:	Follow procedures to adjust the park brake properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

1. Check main brakes for proper adjustment.
2. Engage parking brake.
3. Observe the height of the parking brake pedal.
4. Start car engine.
5. Place the car in gear, and attempt to move car slightly forward.
   Note: *If car moves freely, the parking brake needs adjusting.*
6. Turn off the engine.

7. Raise the car on a lift or jack stands.
8. Inspect the parking brake linkages, cables, and clamps.
9. Repair or replace any damaged parts.



10. Adjust the cable, by turning the adjusting nut several rounds.
11. Test the car again on the floor.
12. If the brakes do not hold, continue to adjust the cables until they function properly.
13. Have instructor check work.
14. Replace tools and equipment.
15. Clean work area.

II-10-JS-10

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Brake and Bearing System

TOPIC: Remove Wheel Bearings

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove wheel bearings correctly.

TOOLS AND EQUIPMENT:

Shop rag
Hydraulic floor jack
Jack stand
Large common screwdriver
Pliers
Box end wrench
Hammer
Brass or bronze bar for a race driver
Glasses or shield.

GENERAL INSTRUCTIONS: Follow procedures to remove the wheel bearings properly.

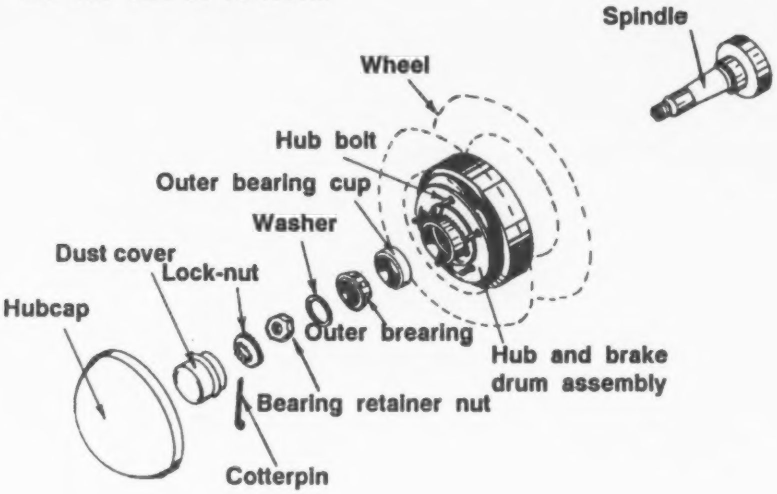
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Set parking brake or chock wheels.
2. Raise the car where the wheel is to be removed.
3. Place the jack stand under the car in a secure position.
4. Remove the hub cap, lug nuts, and roadwheel.
5. Remove the dust cover.
6. Remove the hub nut cotter pin.

7. Remove the bearing adjustment nut.
   Note: *There may be a stamped lock nut that has to be removed before the nut can be removed.*

8. Remove the flat washer.

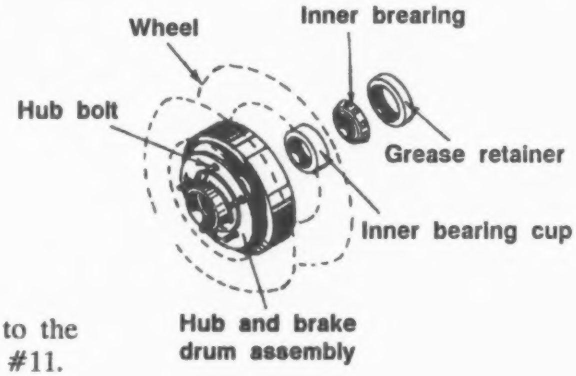
9. Remove the hub assembly.
   CAUTION: Protect the spindle threads during hub removal.
   Note: *Vehicles with disc brakes will have a brake caliper that must be removed before the hub can be removed.*


Spindle
Wheel
Hub bolt
Outer bearing cup
Washer
Dust cover
Lock-nut
Hubcap
Outer brearing
Hub and brake drum assembly
Bearing retainer nut
Cotterpin

10. Remove the front wheel bearing.

11. Remove the rear seal and bearing by carefully tapping the edges of the race through the wheel hub with a brass bar and hammer.

12. Clean the bearings in solvent, removing all old grease. If compressed air is used to dry them, **do not let them spin.** This will gall the races and ruin the bearings.


Wheel
Inner brearing
Hub bolt
Grease retainer
Inner bearing cup
Hub and brake drum assembly

13. If bearings are to be packed, go to the procedures outlined in Job Sheet #11.

14. Have instructor check work.

15. Replace tools and equipment.

16. Clean work area.

II-10-JS-11

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Brake and Bearing System

TOPIC: Clean, Inspect and Pack Bearings

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to clean, inspect and pack bearings correctly.

TOOLS AND EQUIPMENT:

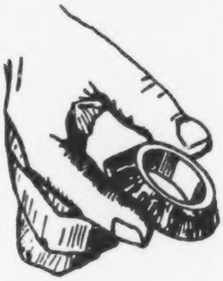
- Shop rag
- Cleaning vat with cleaning fluid
- Brush
- Appropriate wheel bearing grease
- Removed wheel bearings
- Parts tray

GENERAL INSTRUCTIONS: Follow procedures to clean, inspect and pack bearings properly.

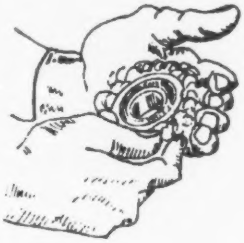
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Wipe excess grease from the bearings.
2. Place bearings and wheel hub parts in a tray.
3. Soak parts in the solvent vat.
   CAUTION: Do not use gasoline to clean parts.
4. Place bearings on a clean rag and allow to dry.

5. Check bearings for cracks, burrs, corrosion, dents, and other visible damage.
   Note: *If a bearing is damaged, it should be replaced.*



6. Place a gob of grease on the palm of one hand.
7. Press the sides of the roller bearings into the grease.



8. Continue this packing process until grease has been forced through the entire bearing.
   Note: *Protect greased bearing from dust and dirt.*
9. If bearings are ready to be replaced, go on to the procedures outlined in Job Sheet #5.
10. Have instructor check work.
11. Replace tools and equipment.
12. Clean work area.

II-10-JS-12

JOB SHEET

MINOR AUTOMOTIVE MAINTENENCE

NAME ______________________________ **DATE** ____________________

UNIT: Brake and Bearing System

TOPIC: Install Wheel Bearings

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(1)(D)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to install wheel bearings correctly.

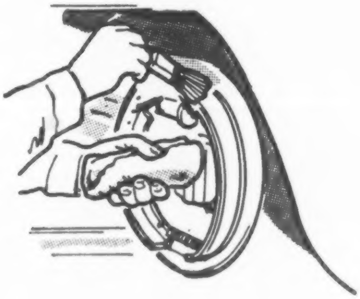
TOOLS AND EQUIPMENT:

Hydraulic floor jack
Jack stand
Shop rag
Side cutter pliers
Box end wrench
Rubber mallet
New cotter pin
Container of solvent
Brush
Brass bar for a race driver
Hammer
Auto manual
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to install wheel bearings correctly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Clean spindle with a brush and clean solvent.



2. Wipe clean with a clean rag.

3. Install the rear wheel race with a brass bar and hammer.
   CAUTION: Be careful not to damage the bearing surface of the race.

4. Place the rear bearing in place.

5. Tap the rear seal gently into place with the rubber mallet.

6. Remove any oil, grease, or solvent from the brake shoes with a clean rag.

7. Slide the wheel hub straight onto the spindle.
   Note: *Replace the brake caliper if vehicle has disc brakes.*

8. Insert outer bearing race if it was removed.

9. Insert outer bearing.

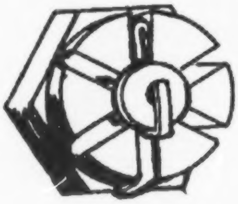
10. Install thrust washer and nut.

11. Adjust the wheel bearings to manufacturer's specifications.

12. If the auto manual does not specify the adjustment, tighten the nut until the wheel becomes hard to turn and then back the nut off ¼ turn.

13. Install lock nut.

14. Install a new cotter pin.
    Note: *Make sure the cotter pin is bent over against the spindle and lock nut. Clip any excess cotter pin off with the side cutter pliers.*



15. Install the dust cover with the rubber mallet.

16. Install the hub cap with the rubber mallet.

17. Remove the jack stand.

18. Lower the vehicle to the floor.

19. Have instructor check work.

20. Replace tools and equipment.

21. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT: Frame, Suspension and Steering

TOPIC: Frame, Suspension and Steering

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to identify major steering and suspension components.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to repair and replace parts of the steering and suspension system.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with frame, suspension and steering include mathematical principles, reading concepts and oral and written communications.*

Frame, Suspension and Steering

The frame, suspension and steering systems are interrelated. Each system's function depends on the other. The alignment of the frame and wheels determines the type of steering stability the vehicle will have. If alignment is improper, the vehicle will shimmy and be difficult to control. This will cause excessive wear of front end parts and tires. When the frame and wheels are properly aligned, the vehicle will follow the road with little steering effort.

The suspension system supports the weight of the car, provides for the dampening of road shocks and permits even and positive steering. The components of the suspension are springs, shock absorbers, struts, axles, tension bars, stabilizer bars, wheels and tires.

Terms and Definitions

Ball joint is a flexible joint with a ball-and socket type of construction that is used in steering linkages.

Coil spring is a spirally wound spring used on front and rear suspensions.

The **control arm** holds the hub assembly, upper and lower ball joints and shock absorbers, and assists in holding coil springs in place.

The **grommet** is an eyelet of rubber that protects an opening or insulates something passed through it.

Idler arm is an L-shaped rod that mounts to the frame and the intermediate rod that helps support the steering linkage.

Intermediate rod is the center link of the steering linkage.

Leaf spring is a flat steel suspension spring made of one or more pieces that is used mainly on the rear axle assembly.

Retainer cup is a cup-shaped metal washer used to hold the grommet in place.

Shackle is a bracket used for mounting leaf springs to the frame.

Shock absorber is a tubular, oil-filled device that absorbs action of the springs.

Spindle assembly is the mounting of upper and lower ball joints, brake-backing plate, front-wheel hub, and tie rod ends.

Stabilizer bar is a springy steel bar mounted to the frame and lower control arm to control body sway and leaning when cornering.

Steering column is a tubular housing mounted to the dash that contains a steering gear shaft to which the steering wheel is mounted.

Steering gear is a gear box located on the end of the steering column that contains the gears necessary to multiply the turning force.

Strut shaft extends from the frame to hold one end of the shock absorber.

Stud is a straight or tapered metal rod with threads on either or both ends.

Upper mounting bracket is a piece of metal that extends from the frame at the location of each spring assembly and holds one end of the shock absorber.

Types of Frames

The **conventional type frame** is constructed as a separate unit. The body is bolted at designated points. Rubber installation blocks are installed between the frame and body at these points to minimize the transfer of vibrations.

The conventional type frame is quite rigid because the suspension, engine and body depend on the frame to support and maintain all units in alignment.

The **integral body and frame** are a single unit with the body sections welded to the frame to help support and stiffen the entire unit.

Types of Suspension Systems

Solid axle-leaf spring suspension consists of a number of flat steel springs in various lengths which are bolted together.

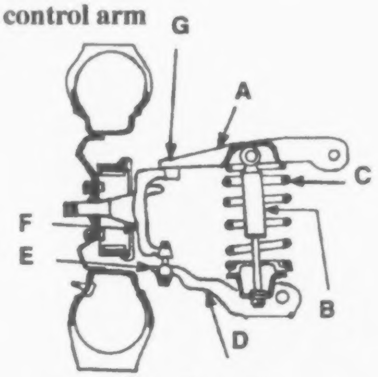
Independent coil-spring suspension is heated and wound in the shape of a spiral coil. Pads are attached to both ends to reduce vibration transfer.

Advantages of independent suspension

- Keeps wheels aligned and allows each wheel to move up and down freely with minimum effect on the other wheel.
- Does not transfer twisting action to the body and frame.

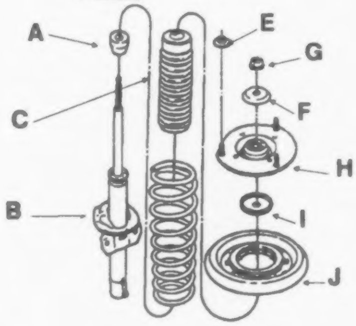
Components of the front suspension, coil spring with control arm

A. Upper control arm
B. Shock absorber
C. Coil spring
D. Lower control arm
E. Lower ball joint
F. Steering knuckle
G. Upper ball joint



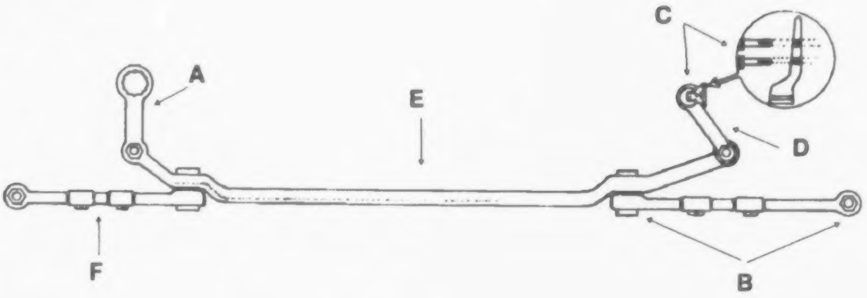
Components of McPherson strut suspension

A. Bounce bumper
B. Strut
C. Dust boot
D. Spring
E. Nut (3 required)
F. Washer
G. Nut
H. Top mount bracket assembly
I. Washer
J. Bearing and seat assembly



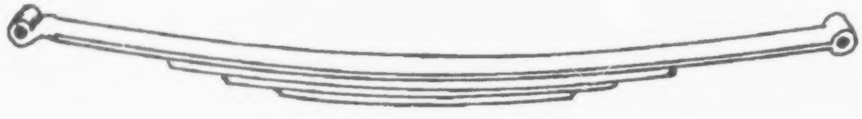
Components of the steering linkage

A. Pitman arm
B. Tie rod
C. Idler arm support
D Idler arm
E. Center link
F. Adjustment sleeve

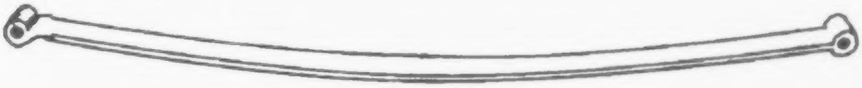


Types of springs

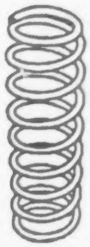
A. Multi-leaf



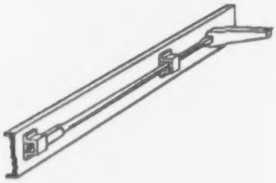
B. Single-leaf



C. Coil

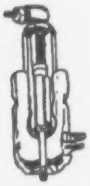


D. Torsion-bar

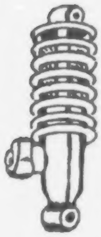


Types of shock absorbers

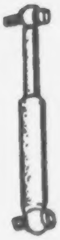
A. Air adjustable



B. Superlift

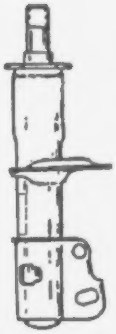


C. Telescopic

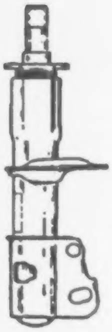


D. Struts

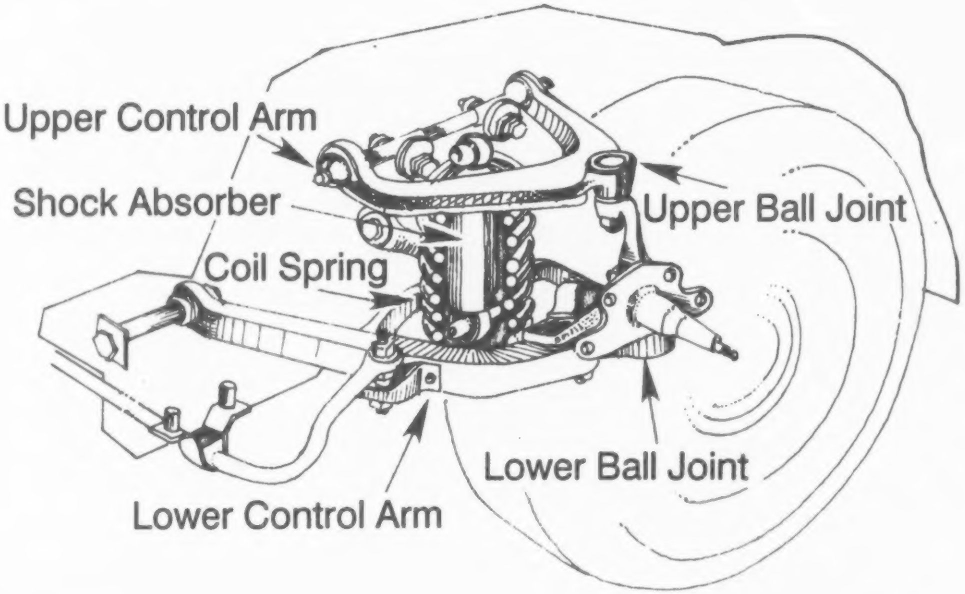
Sealed strut



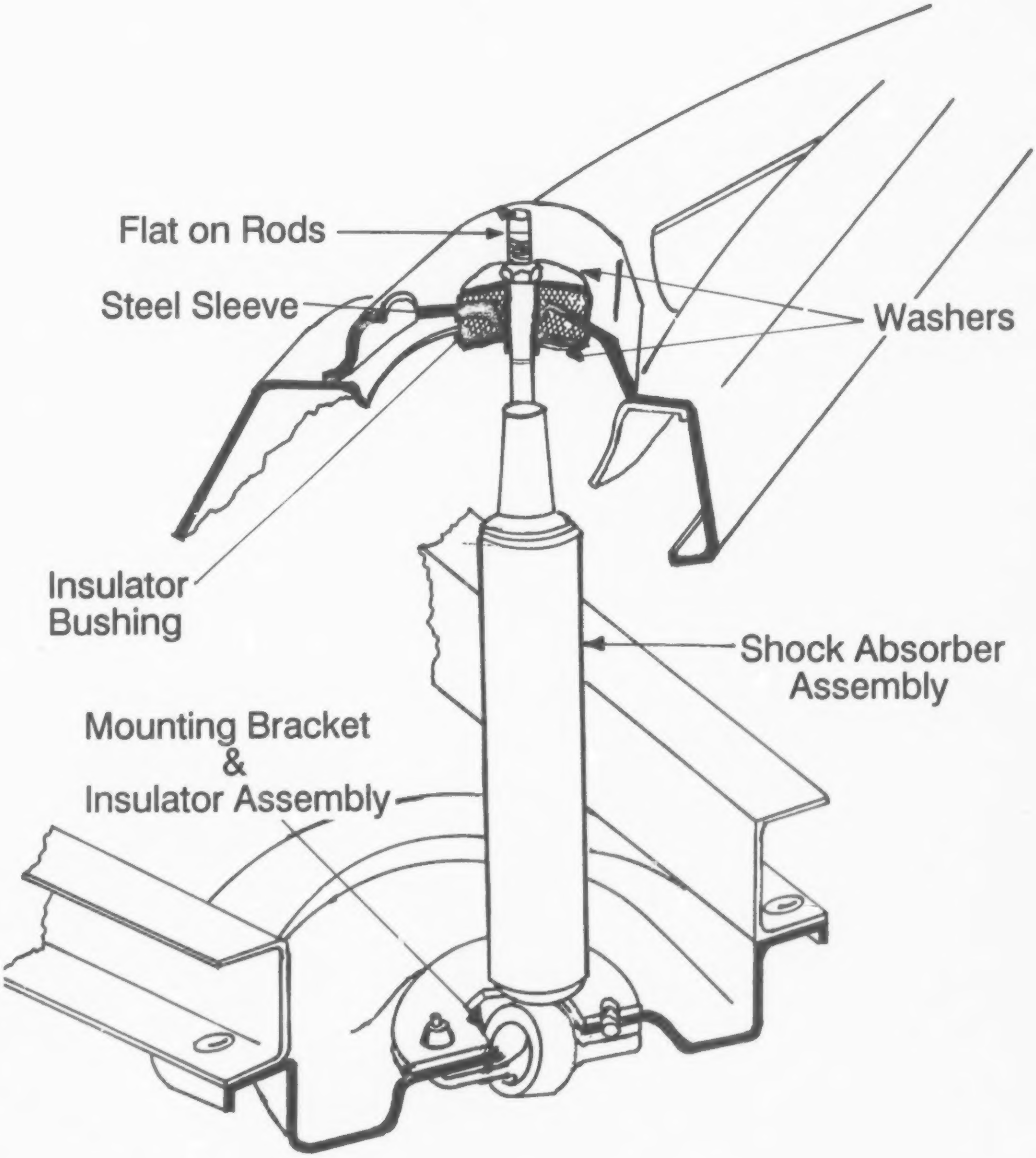
Serviceable



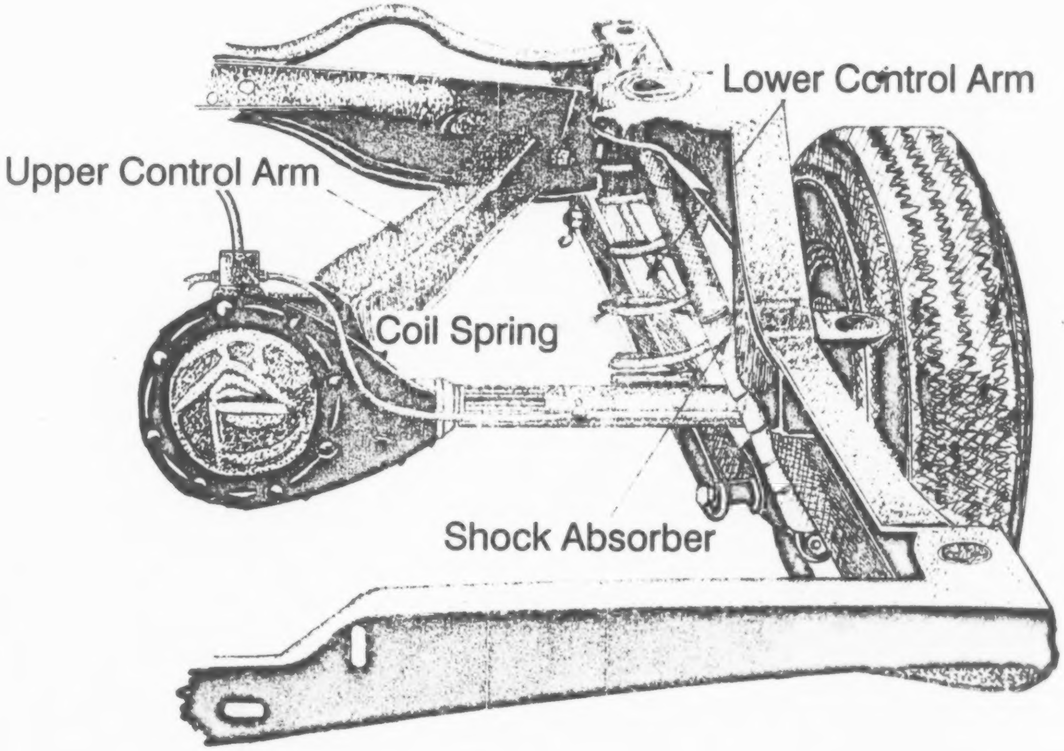
The Front Suspension


Upper Control Arm
Shock Absorber
Coil Spring
Upper Ball Joint
Lower Ball Joint
Lower Control Arm

Shock Absorber Mounting

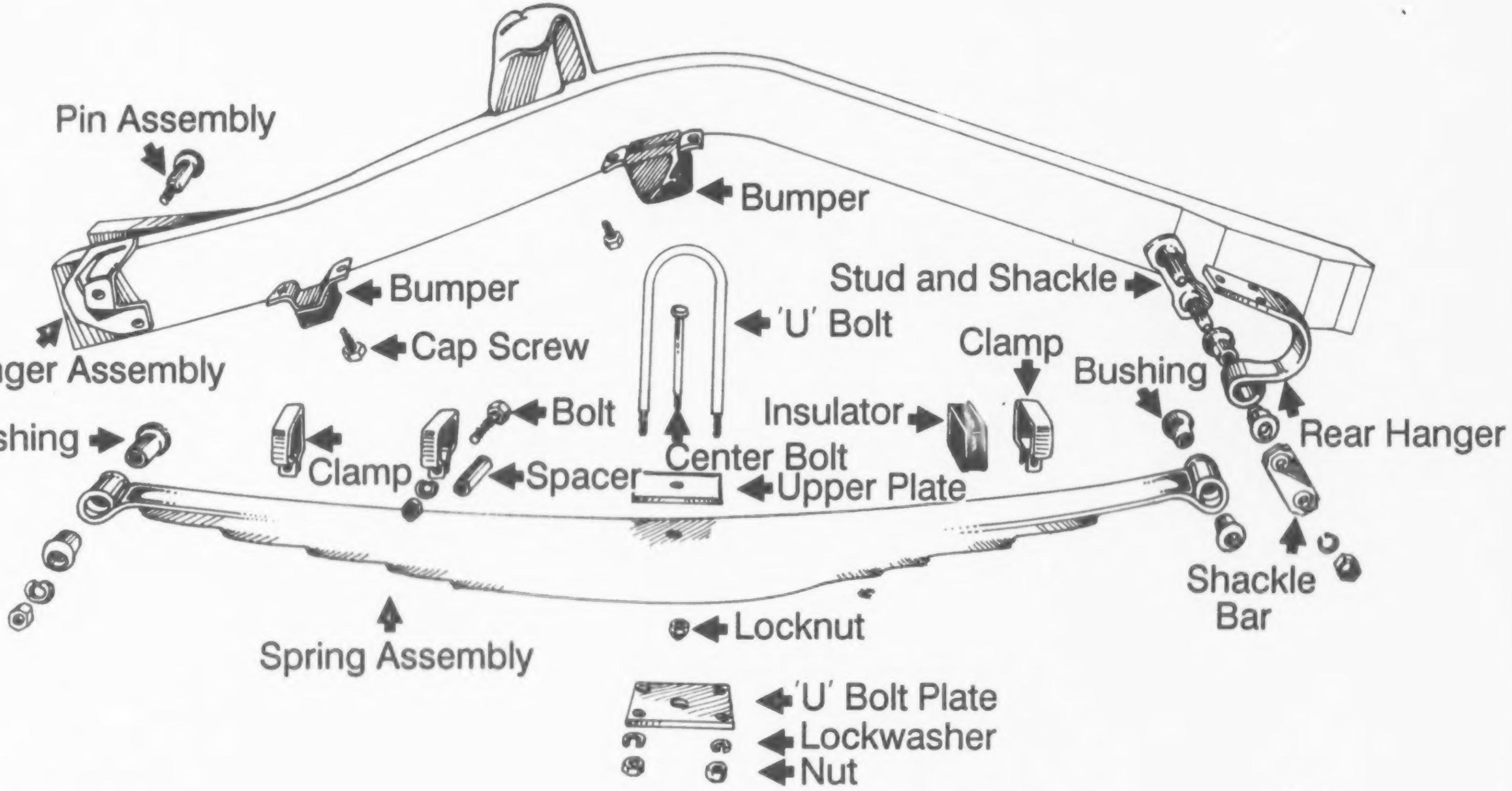

Flat on Rods
Steel Sleeve
Washers
Insulator Bushing
Shock Absorber Assembly
Mounting Bracket & Insulator Assembly

Rear Suspension Coil Spring


Lower Control Arm
Upper Control Arm
Coil Spring
Shock Absorber

TM-3

Rear Suspension Leaf Spring


Pin Assembly
Bumper
Hanger Assembly
Bumper
Cap Screw
Stud and Shackle
'U' Bolt
Clamp
Bushing
Bolt
Insulator
Rear Hanger
Bushing
Clamp
Center Bolt
Spacer
Upper Plate
Shackle Bar
Spring Assembly
Locknut
'U' Bolt Plate
Lockwasher
Nut

TM-4

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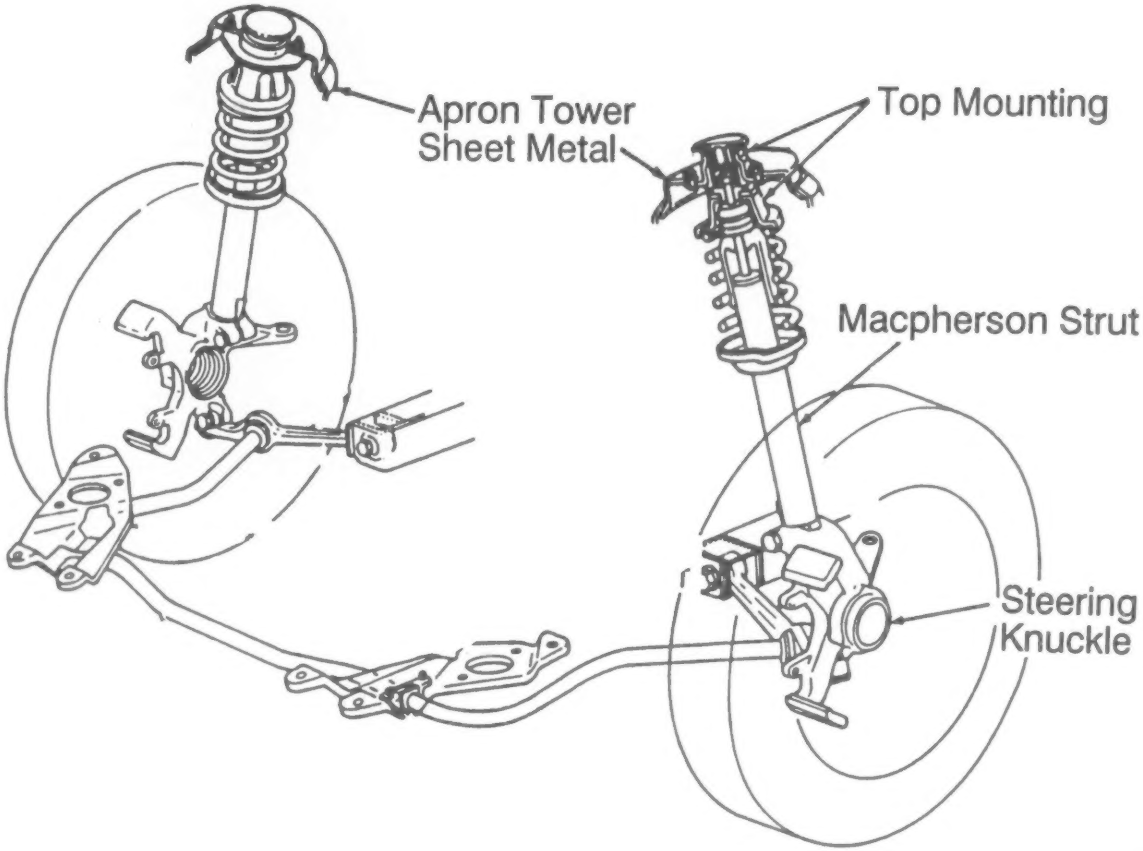
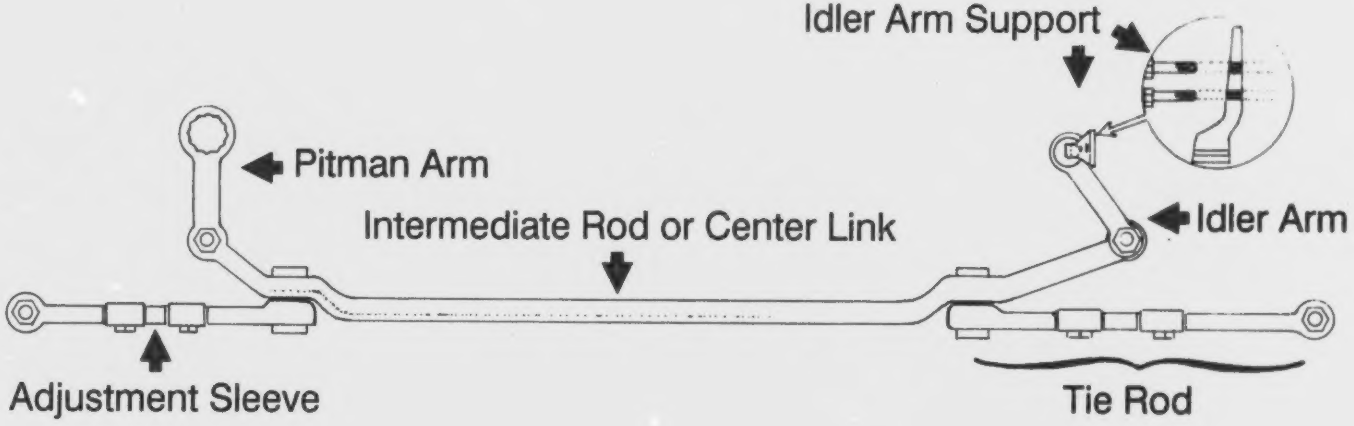
MacPherson Strut


Apron Tower Sheet Metal
Top Mounting
Macpherson Strut
Steering Knuckle

Front Suspension Components

Typical Steering Linkage



Idler Arm Support

Pitman Arm

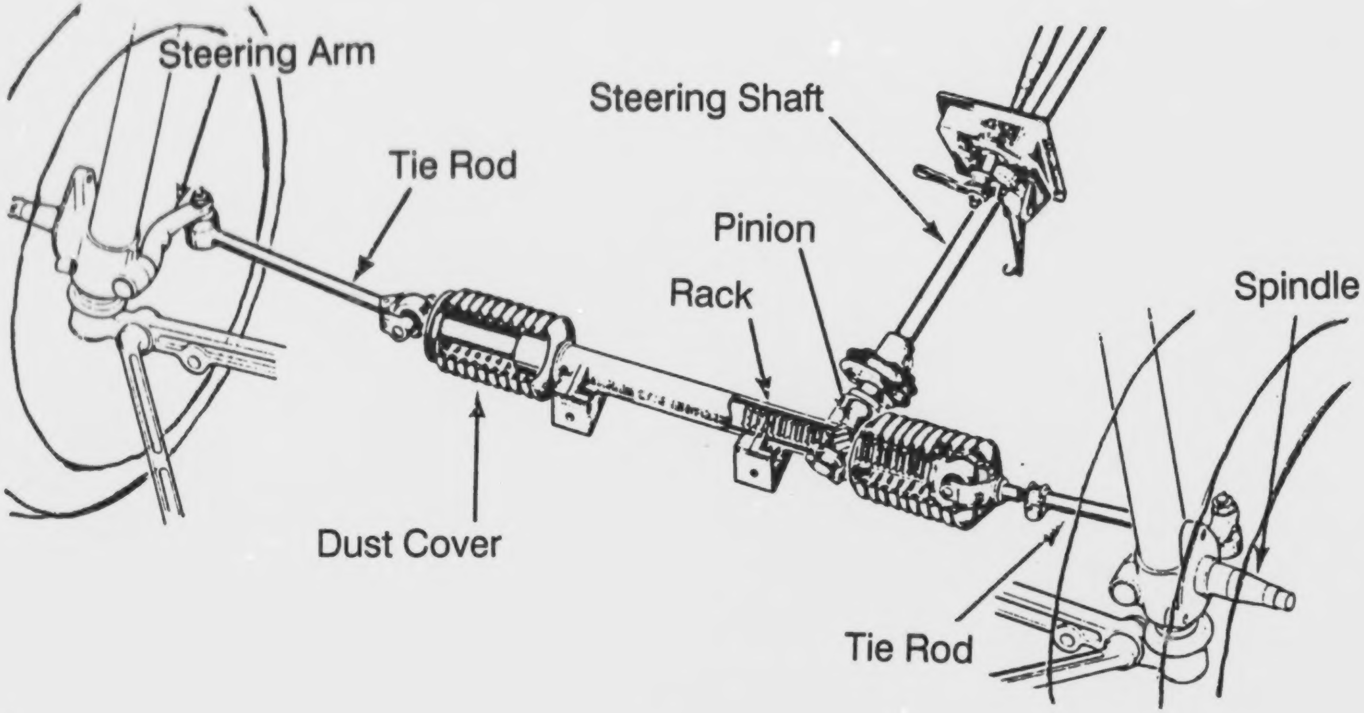
Intermediate Rod or Center Link

Idler Arm

Adjustment Sleeve

Tie Rod

Rack and Pinion Steering


Steering Arm
Steering Shaft
Tie Rod
Pinion
Rack
Spindle
Dust Cover
Tie Rod

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT: Frame, Suspension and Steering

TOPIC: Frame, Suspension, Steering

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms and definitions associated with frame, suspension and steering.

_____a. Holds the hub assembly, upper and lower ball joints, shock absorbers, and assists in holding coil springs in place

_____b. An eyelet of rubber that protects an opening or insulates something passed through it

_____c. A tubular oil-filled device that absorbs action of the springs

_____d. A cup-shaped metal washer used to hold the grommet in place

_____e. A piece of metal that extends from the frame at the location of each spring assembly to hold one end of the shock absorber.

_____f. A shaft extending from the frame to hold one end of the shock absorber

_____g. The mounting of upper and lower ball joints, brake backing plate, front wheel hub, and tie rod ends

_____h. Brackets used for mounting leaf springs to the frame

1. Grommet
2. Strut shaft
3. Control arms
4. Upper mounting bracket
5. Shock absorber
6. Retainer cup
7. Shackle
8. Intermediate rod
9. Stud
10. Coil Spring
11. Spindle assembly
12. Ball joint
13. Idler arm
14. Stabilizer

_____i. An L-shaped rod that mounts to the frame and the intermediate rod that helps support the steering linkage

_____j. The center link of the steering linkage

_____k. A flexible joint with a ball-and-socket type of construction that is used in steering linkage

_____l. A straight or tapered metal rod with threads on either or both ends

_____m. A springy steel bar mounted to the frame and lower control arm to control body sway and leaning when cornering

_____n. A spiral-wound spring used on front and rear suspensions

_____o. A flat spring-steel suspension spring made of one or more pieces and used mainly on the rear axle assembly

_____p. A gear box located on the end of the steering column that contains the gears necessary to multiply the turning force

_____q. A tubular housing mounted to the dash that contains a steering gear shaft to which the steering wheel is mounted

15. Steering gear

16. Leaf spring

17. Steering column

2. Identify the two types of frames described below as either a "conventional type" or an "integral type."

____________________a. The frame and body are a single unit with all sections welded together.

____________________b. The frame is a separate part, and the body is bolted together.

3. List the two types of suspension systems.

a.

b.

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4. Point out the advantages of independent suspension by placing a " √ " in front of each.

_____a. Keeps wheels aligned

_____b. Prevents flat tires

_____c. Eliminates the use of shock absorbers

_____d. Does not transfer the twisting action of the body

5. Identify the components of the front suspension from the list.

lower ball joint
upper control arm
coil spring
upper ball joint
lower control arm
steering knuckle
shock absorber

a. ____________________

b. ____________________

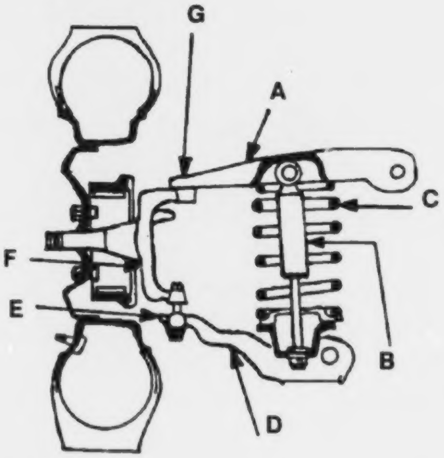
c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________



6. Identify the components of the steering linkage from the list.

tie rod
idler arm
Pitman arm
idler arm support
center link
adjustment sleeve

a. ____________________

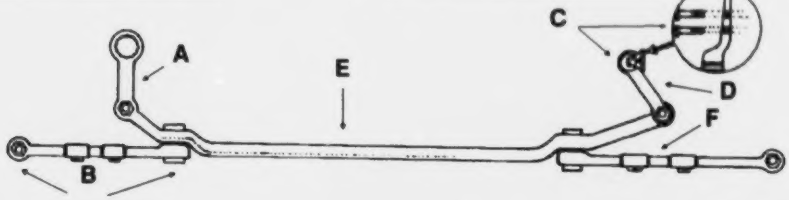
b. ____________________

c. ____________________

d. ____________________

e. ____________________

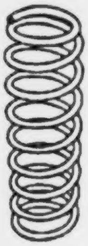
f. ____________________



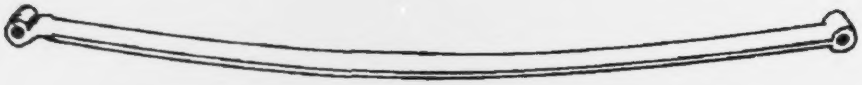
7. Identify each of the types of springs from the list.

multi-leaf spring	single leaf spring
coil spring	torsion bar spring

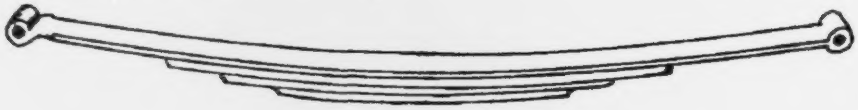
a. ____________________



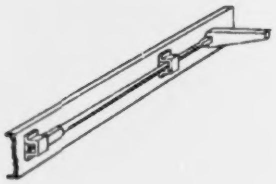
b. ____________________



c. ____________________



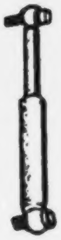
d. ____________________



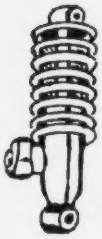
8. Identify each of the types of shock absorbers from the list.

Superlift
Adjustable
Telescopic
Strut

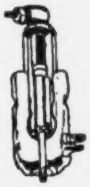
a. ____________________



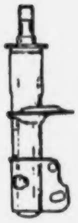
b. ____________________



c. ____________________



d. ____________________



II-11-JS-1

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Frame, Suspension and Steering

TOPIC: Remove and Replace Front Shock Absorber

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1) (A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace front shock absorber correctly.

TOOLS AND EQUIPMENT:

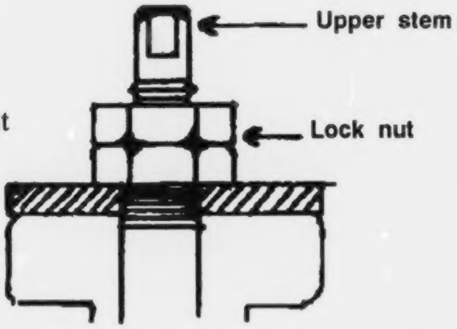
Socket set
Combination wrenches
Box-end wrench set
Pry bar

Hydraulic floor jack
Two jack stands
Torque wrench
Auto manual

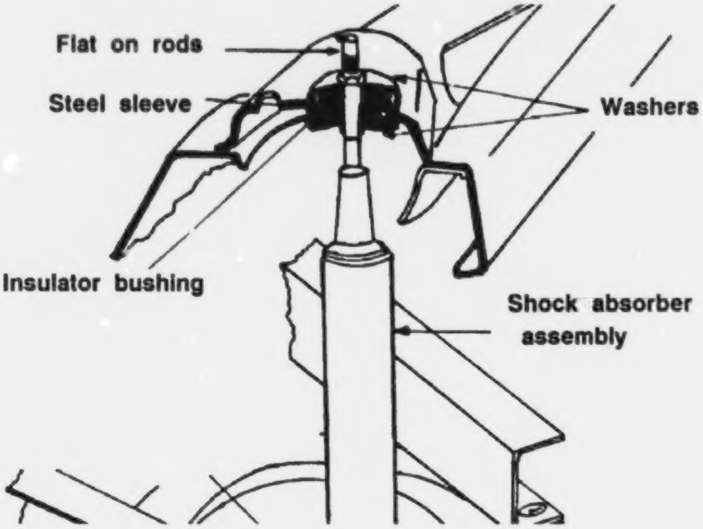
GENERAL INSTRUCTIONS: Follow procedures to remove and replace the front shock absorber properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise front of car enough to place jack stands.
2. Place jack stands in a secure position.
3. Remove the upper stem nut with a box-end wrench while holding the stem with a crescent wrench.
   Note: *A lock nut may need to be removed.*



4. Remove the lower retaining bolts that hold the shock absorber to the lower control arm.
5. Pull the shock absorber through the control arm.
6. Pull the new shock absorber until it is fully extended.
7. Insert the shock absorber through the lower control arm.
8. Place the retainer cup and a grommet on the stem of the shock absorber.
9. Guide the stem through the upper control arm mounting hole.
10. Install the lower retaining bolts through the lower shock absorber mounting holes in the lower control arm.



11. Tighten the bolt to 12 foot-pounds of pressure with the torque wrench.
    Note: *Torque settings may vary, so check the auto manual for exact settings.*
12. Install the top grommet, retainer cup, and nut on the shock absorber stem.
13. Hold the shock absorber stem and tighten the stem nut.
14. Install the lock nut if available.
15. Raise car with a jack.

16. Remove jack stands, lower car to the floor.
17. Have instructor check work.
18. Replace tools and equipment.
19. Clean work area.

II-11-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Frame, Suspension and Steering

TOPIC: Remove and Replace Rear Shock Absorber

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the rear shock absorber correctly.

TOOLS AND EQUIPMENT:

Socket set
Box-end wrench set
Pry bar
Hydraulic floor jack
Two jack stands
Torque wrench
Auto manual

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the rear shock absorber properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise rear of car enough to place jack stands.

2. Place jack stands in a secure position. Reposition the floor jack under the rear axle or A-frame for support. When the shock is removed, the axle will drop.

3. Disconnect air line to shock absorber if car is equipped with air shock absorbers.

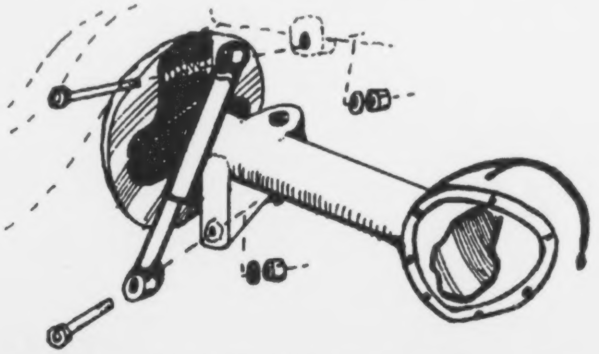
4. Remove either the upper retaining nut or the two retaining bolts from the upper mounting bracket.

5. Remove the retaining nut on the lower end of the shock absorber while holding the hex head bolt with a backup wrench.

6. Remove the shock absorber.

7. Put new shock absorber in place.

8. Install the retaining unit on two retaining bolts in the top mounting bracket.
   Note: *Check to see if grommets are properly installed.*



9. Torque the retaining nut or bolt to 30 foot-pounds pressure.
   Note: *Torque settings may vary, so check the auto manual for exact settings.*

10. Extend the shock absorber to the length required for bolt alignment.

11. Install bolt in lower bracket and shock absorber.

12. Install lock washer and retaining nut.

13. Torque nut to 65 foot-pounds pressure.
    Note: *Torque settings may vary, so check the auto manual for exact settings.*

14. Connect air line if air shocks are installed.

15. Raise car with a jack.

16. Remove jack stands.

17. Lower the car to the floor.

18. Have instructor check work.

19. Replace tools and equipment.

20. Clean work area.

II-11-JS-3

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Frame, Suspension and Steering

TOPIC: Remove and Replace Tie Rod End

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the tie rod end correctly.

TOOLS AND EQUIPMENT:

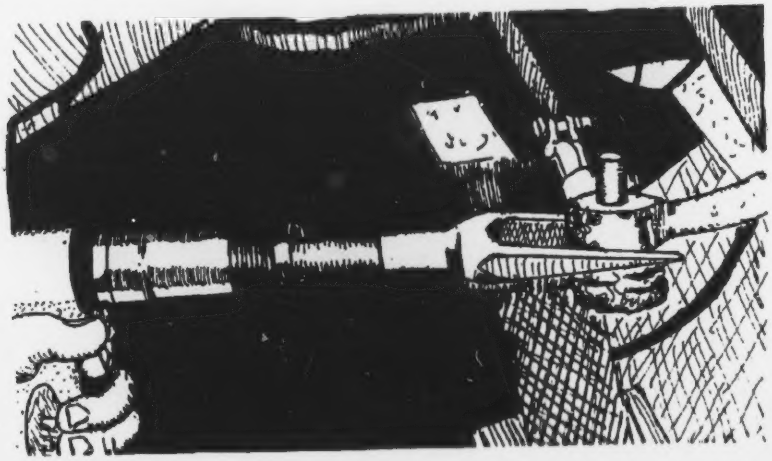
- Ball peen hammer
- Two jack stands
- Needle nose pliers
- Safety glasses
- 3/8-in. drive socket set
- Pry bar
- Box-end wrench set
- Cotter pins
- Lug wrench
- Rubber mallet
- Tie rod end puller
- Hydraulic floor jack

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the tie rod end properly.

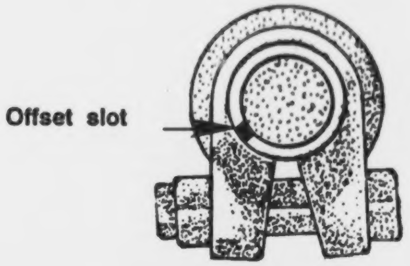
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise the front of the car enough to place jack stands.
2. Place jack stands in a secure position.
3. Remove front wheel cover.
4. Remove wheel.
5. Loosen tie rod sleeve clamp bolt.

6. Remove the cotter pin from the tie rod end stud nut.
7. Remove tie rod end stud from the steering knuckle with tie rod end puller.

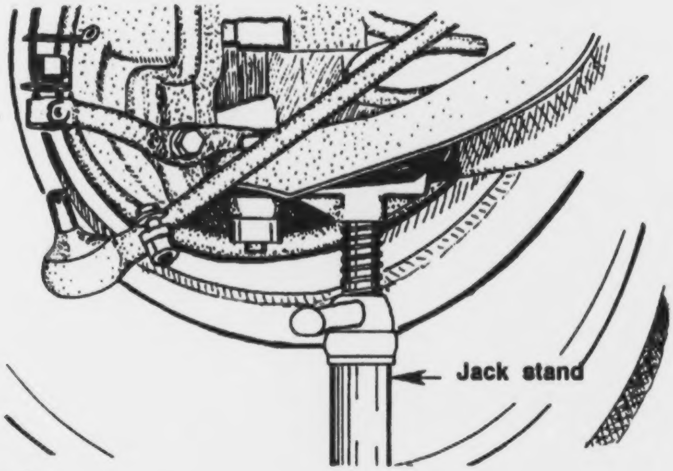


8. Remove the outer tie rod end from the adjuster sleeve by turning the tie rod end counterclockwise.
   Note: *Count the number of turns when removing the tie rod end from the sleeve.*
9. Align the clamp opening and sleeve slot properly.



10. Install the new tie rod by turning the tie rod end clockwise the same number of turns as it took to remove the old one.
11. Align the tie rod end stud with the tapered hole of the steering knuckle arm.
12. Insert the stud in the hole.

13. Replace the tie rod end stud nut.



14. Tighten securely.

15. Align slot in stud nut with hole in the stud.

16. Insert a new cotter pin in hole and spread ends.

17. Tighten tie rod sleeve clamp bolts.

18. Install wheel and wheel cover.

19. Raise car with jack.

20. Remove jack stands.

21. Lower the car to the floor.
Note: *Front-end alignment should be checked.*

22. Have instructor check work.

23. Replace tools and equipment.

24. Clean work area.

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II-11-JS-4

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Frame, Suspension and Steering

TOPIC: Remove and Replace Idler Arm

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the idler arm correctly.

TOOLS AND EQUIPMENT:

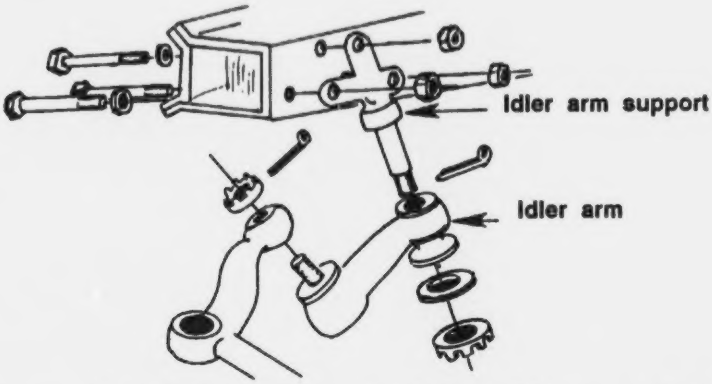
- Socket set
- Box-end wrench set
- Ball peen hammer
- Hydraulic floor jack
- Two jack stands
- Torque wrench
- Grease gun
- Lug wrench
- Pry bar
- Tie rod end puller

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the idler arm properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise the front of the car enough to place jack stands.
2. Place jack stands in a secure position.
3. Remove wheel cover.
4. Remove the tire and wheel.
5. Remove the cotter pin from the intermediate rod stud nut holding the idler arm.
6. Remove the intermediate rod stud holding the idler arm.

7. Remove the idler arm from the intermediate rod stud with a tie rod end puller.
8. Remove the attaching bolts from the idler arm support.
9. Remove the idler arm.



10. Loosely attach the new idler arm support to the frame with new nuts and bolts.
11. Align idler arm hole with intermediate rod stud.
12. Loosely install the intermediate rod stud nut.
13. Tighten the idler arm support bolts to 40 foot-pounds pressure with the torque wrench.
14. Tighten the intermediate rod stud nut.
15. Align the slot in the nut with the hole in the stud.
16. Insert a new cotter pin and spread ends.
17. Install wheel and wheel cover.
18. Raise car with jack.
19. Remove the jack stands.
20. Lower the car to the floor.
21. Have instructor check work.
22. Replace tools and equipment.
23. Clean work area.

STUDENT INFORMATION SHEET
MINOR AUTOMOTIVE MAINTENANCE

UNIT:	Drive Line
TOPIC:	Drive Line
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to identify, adjust, and replace parts of the drive line.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to replace components of the drive line correctly.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with wheels and tires include mathematical principles, oral and written communications and reading concepts.*

Drive Lines

The drive lines must carry the drive thrust. As drive line angles change, a slip joint is needed to allow fore and aft movement. Drive lines must be accurately and carefully balanced to operate at high speeds.

To prevent the speed fluctuation transfer to the pinion shaft, it is essential to have both front and rear propeller shaft yokes in the same plane.

Constant velocity universal joints are used to provide a smooth torque transfer without speed fluctuations.

Terms and Definitions

Clutch disc is a spring-loaded metal plate with a fiber coating that absorbs the shock of engine torque.

Clutch linkage is an adjustable metal rod located between the clutch pedal and clutch throw-out fork.

Clutch pedal is a device located inside the vehicle next to the steering column which allows the drivers to engage or disengage the clutch.

Clutch throw-out fork holds the throw-out bearing in place and is connected to the clutch pedal linkage.

Constant velocity joint is a universal joint designed to make smooth transfer of torque from driver shaft without any fluctuations in speed of driver shaft.

Differential is the last unit of the power train that allows for the different speeds of the rear wheels when turning a corner.

Pressure plate is a metal disc bolted directly to the flywheel that puts pressure on the clutch disc, putting the vehicle in motion.

Propeller (drive) shaft is a tube, with flexible joints at each end, that connects the transmission and the differential.

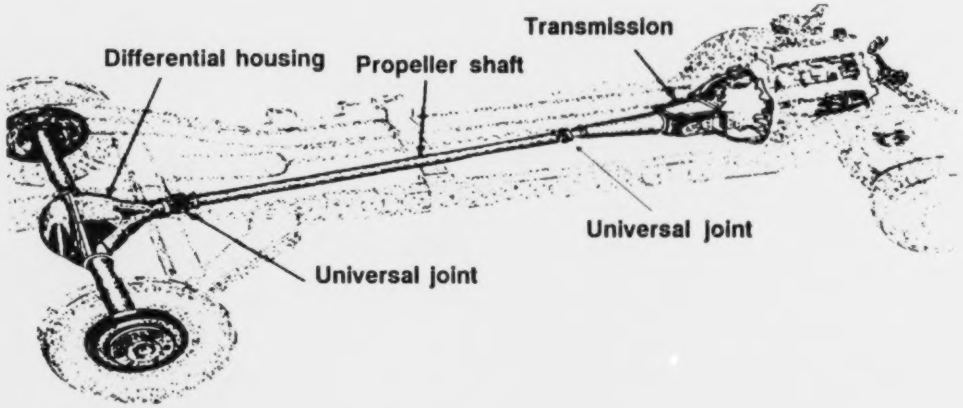
Rear axles transfer the power from the differential to the rear wheels.

Standard transmission is a unit in the power train used with a clutching system that allows the operator to select various gears by manually shifting.

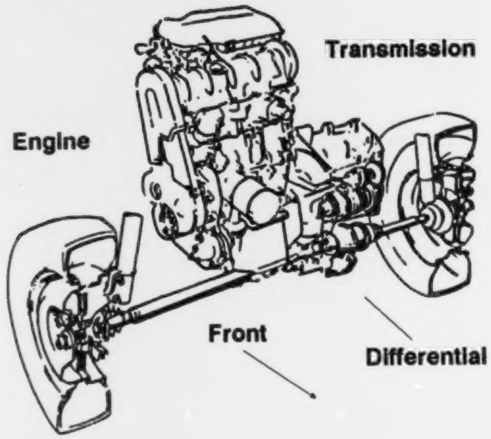
Throw-out bearing depresses the pressure plate fingers which engage the clutch disc.

Universal joints are X-shaped units that allow flexibility in the shaft between the transmission and differential.

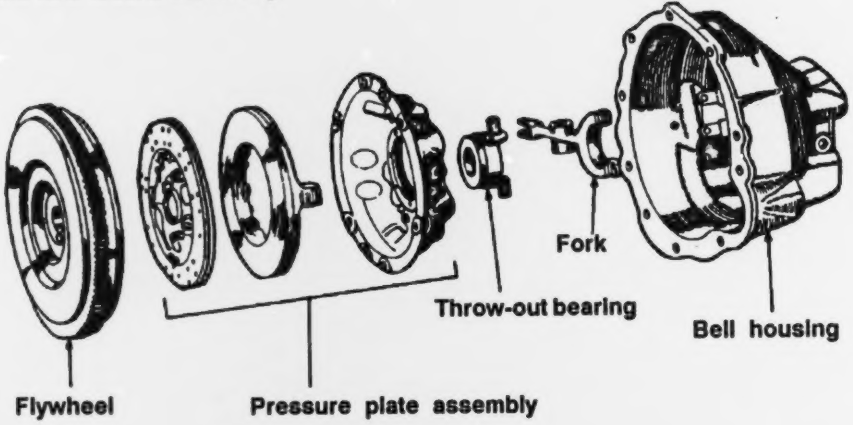
Components of the power train for rear drive



Components of the power train for front wheel drive


Transmission
Engine
Front
Differential

Components of a clutch assembly


Fork
Throw-out bearing
Bell housing
Flywheel
Pressure plate assembly

Standard transmission gear ratios

Gear	Engine revolutions	Driveshaft revolutions
First	3	1
Second	2	1
Third	1	1
Overdrive	.75	1
Reverse	3.5	1

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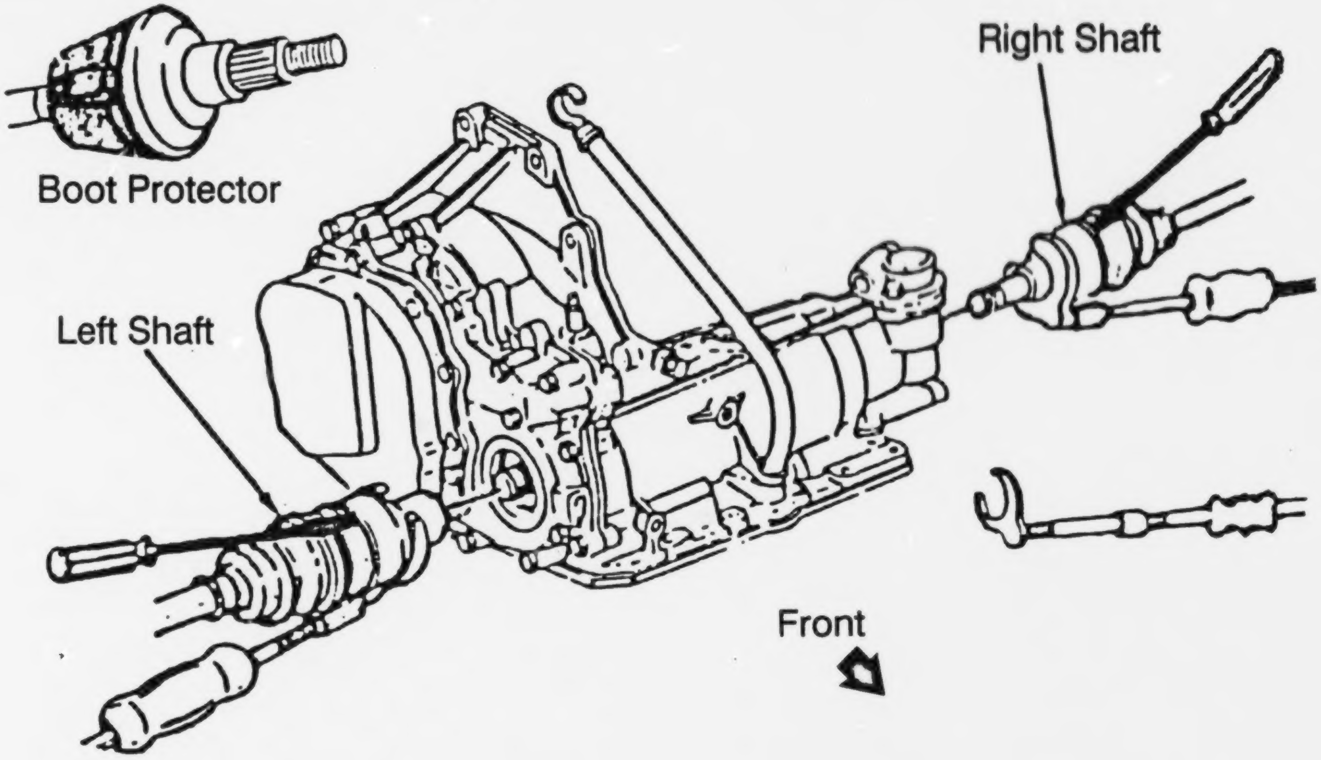
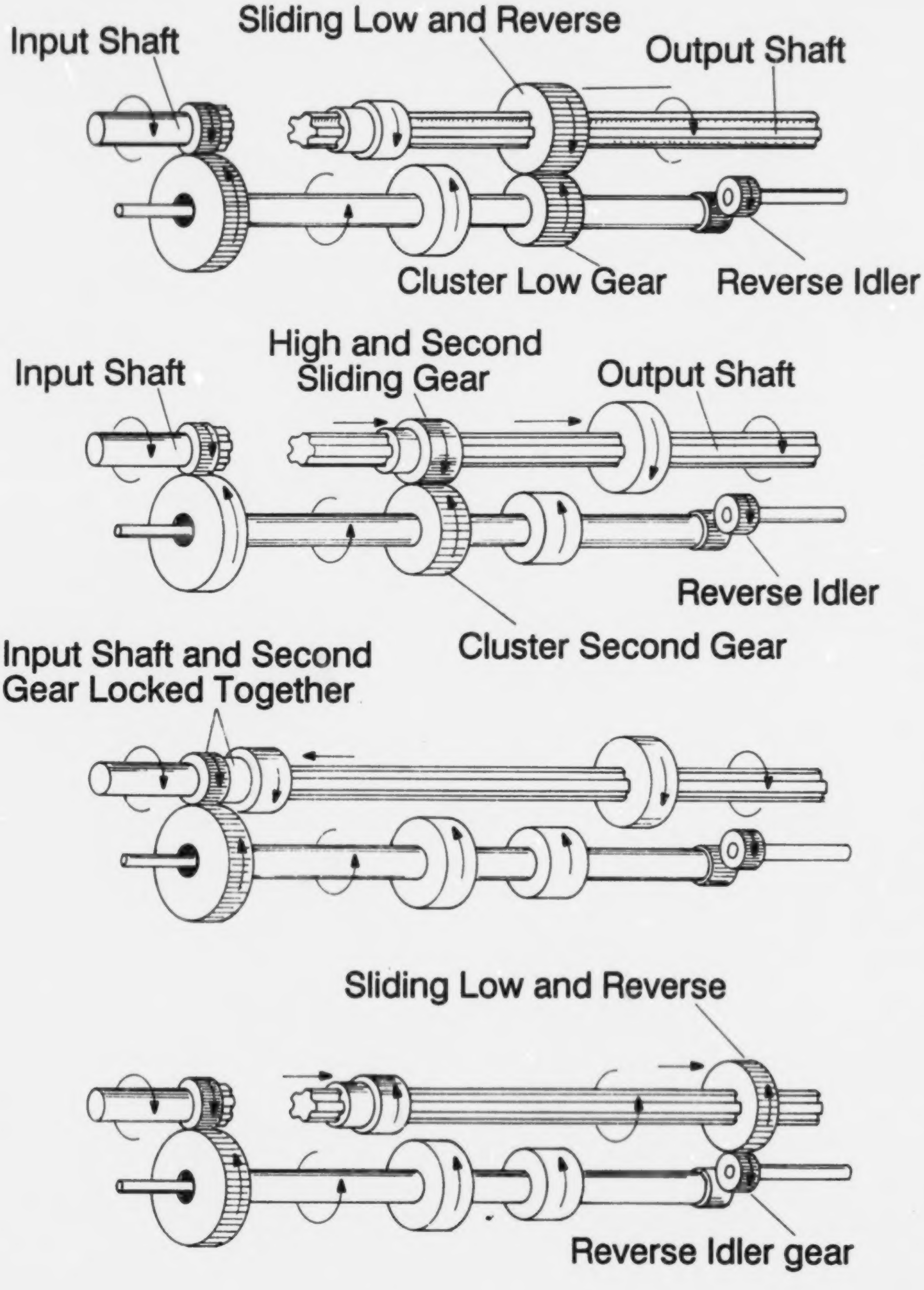
Drive Axle Assembly


Boot Protector
Right Shaft
Left Shaft
Front

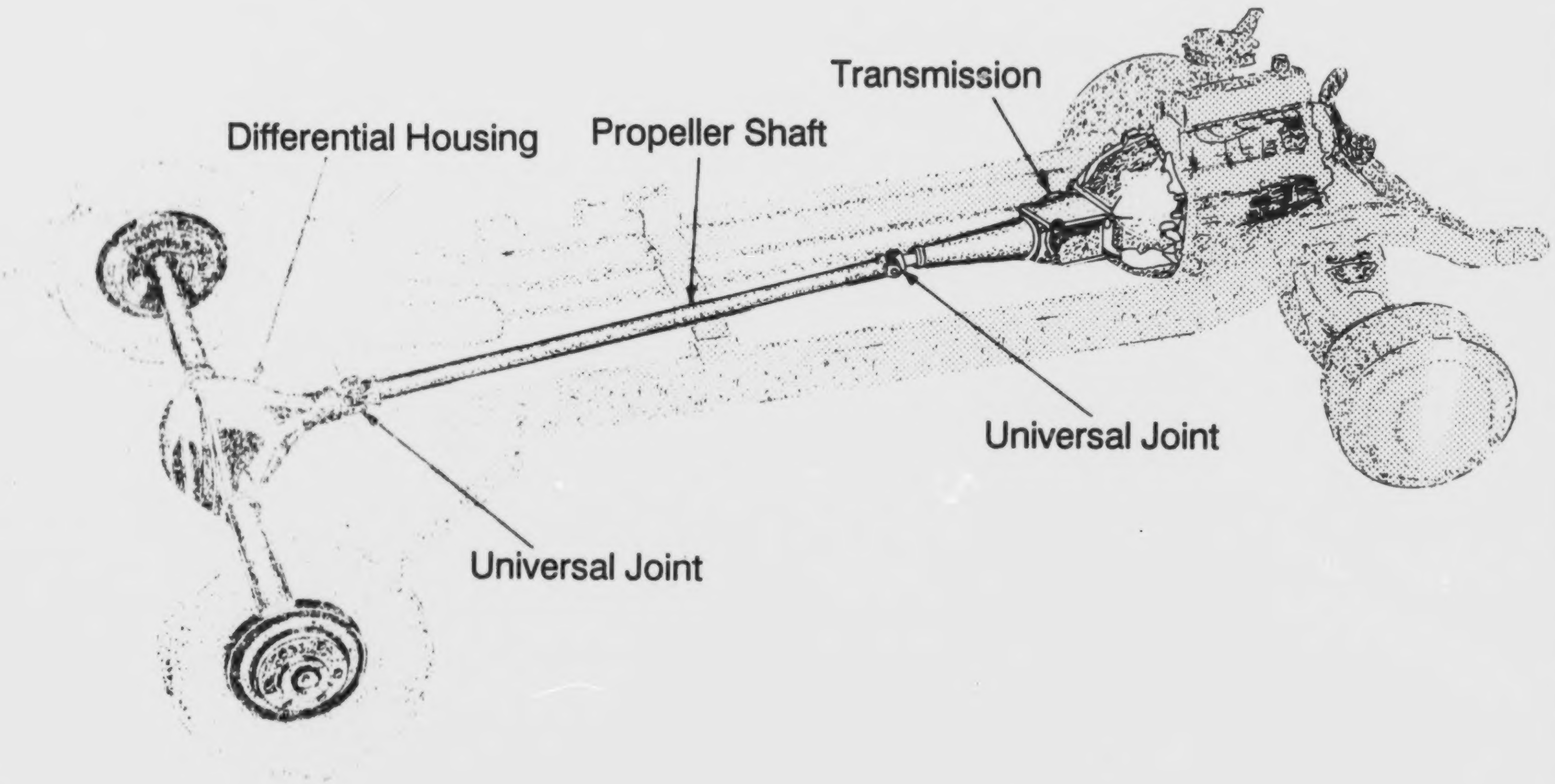
404

405

Transmission Gear Ratios

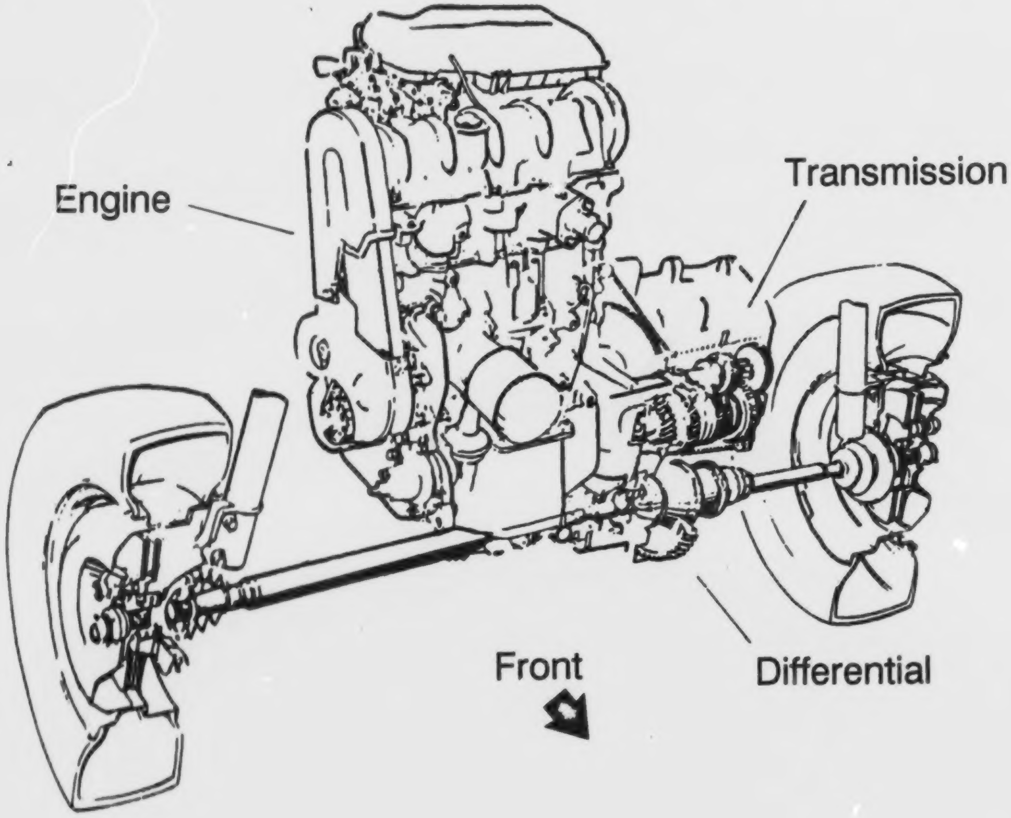

Input Shaft
Sliding Low and Reverse
Output Shaft
Cluster Low Gear
Reverse Idler
Input Shaft
High and Second Sliding Gear
Output Shaft
Reverse Idler
Cluster Second Gear
Input Shaft and Second Gear Locked Together
Sliding Low and Reverse
Reverse Idler gear

Drive Line

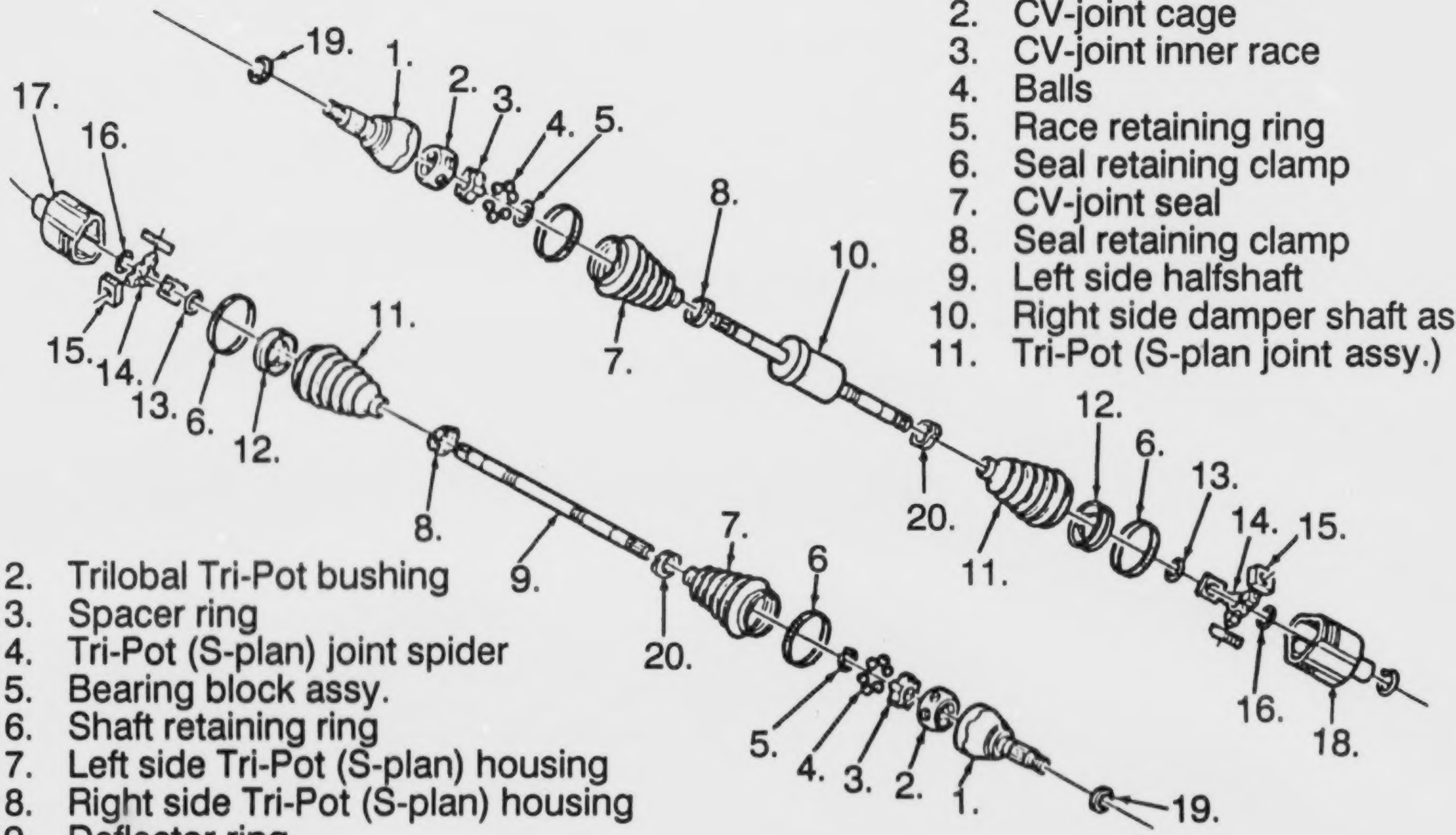

Transmission
Differential Housing
Propeller Shaft
Universal Joint
Universal Joint

TM-3

Drive Line


Engine
Transmission
Front
Differential

Typical Exploded View of the Halfshaft Assemblies


19.
1.
2.
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16.
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13.
6.
12.
12.
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9.
11.
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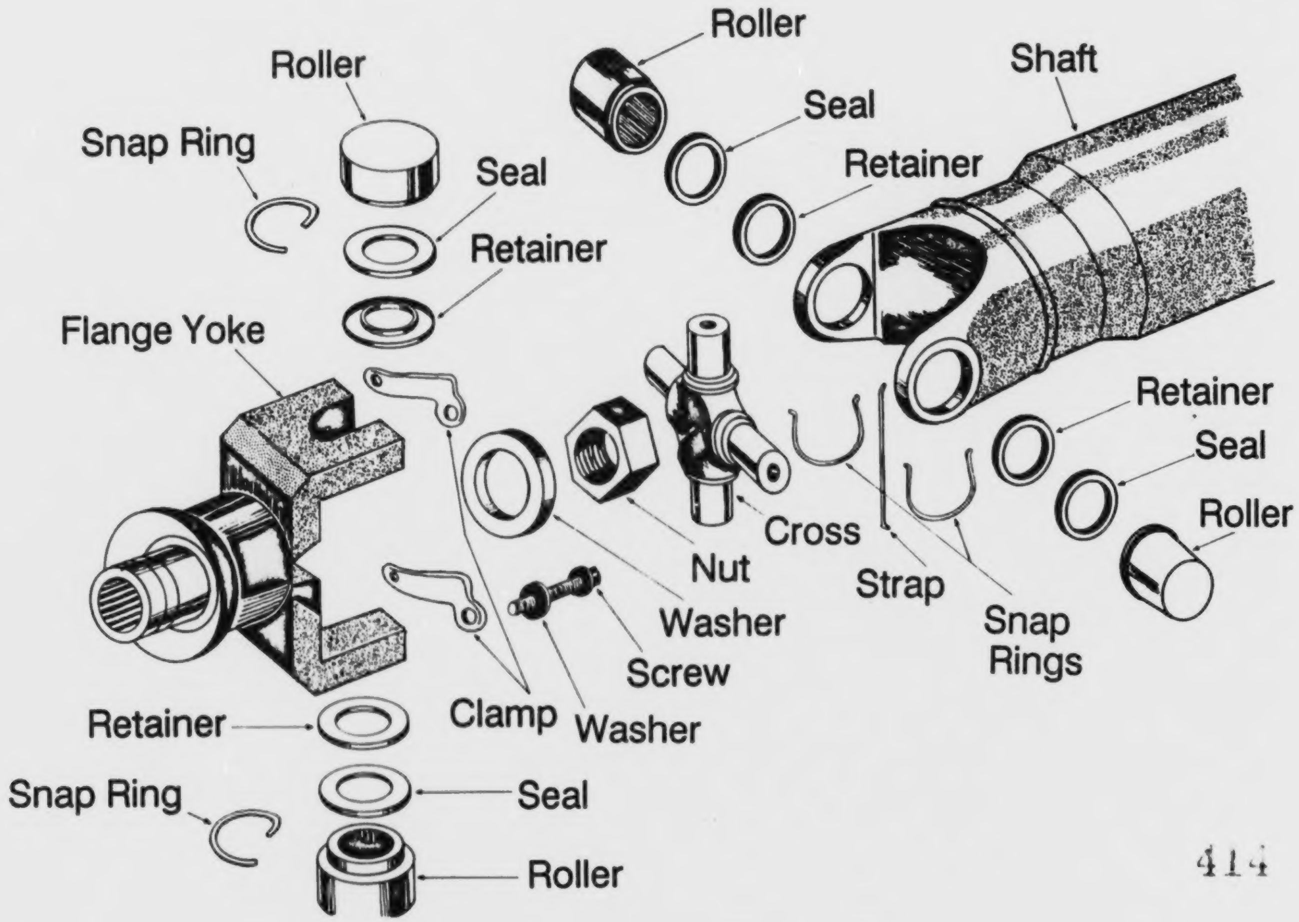
16.
18.
5.
4.
3.
2.
1.
19.

1. CV-joint outer race
2. CV-joint cage
3. CV-joint inner race
4. Balls
5. Race retaining ring
6. Seal retaining clamp
7. CV-joint seal
8. Seal retaining clamp
9. Left side halfshaft
10. Right side damper shaft assy.
11. Tri-Pot (S-plan joint assy.)
12. Trilobal Tri-Pot bushing
13. Spacer ring
14. Tri-Pot (S-plan) joint spider
15. Bearing block assy.
16. Shaft retaining ring
17. Left side Tri-Pot (S-plan) housing
18. Right side Tri-Pot (S-plan) housing
19. Deflector ring
20. Joint retaining ring

Universal Joint


Roller
Shaft
Roller
Seal
Snap Ring
Seal
Retainer
Retainer
Flange Yoke
Retainer
Seal
Cross
Roller
Nut
Strap
Washer
Snap
Rings
Screw
Clamp
Washer
Retainer
Seal
Snap Ring
Roller

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TM-6

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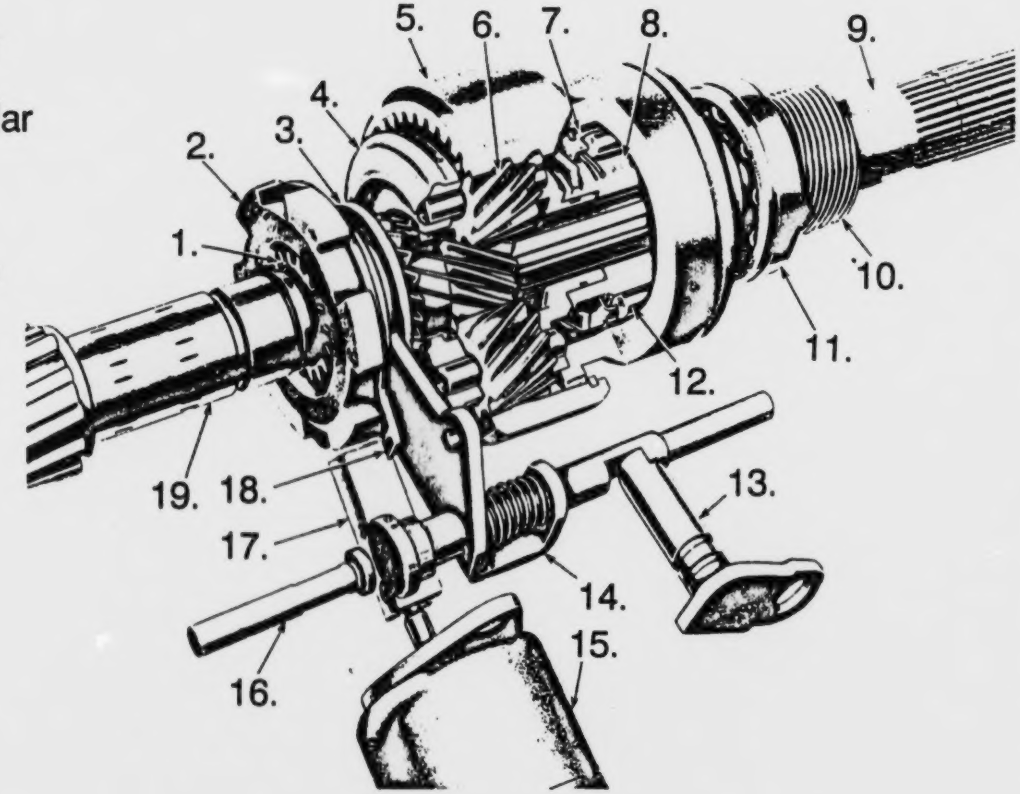
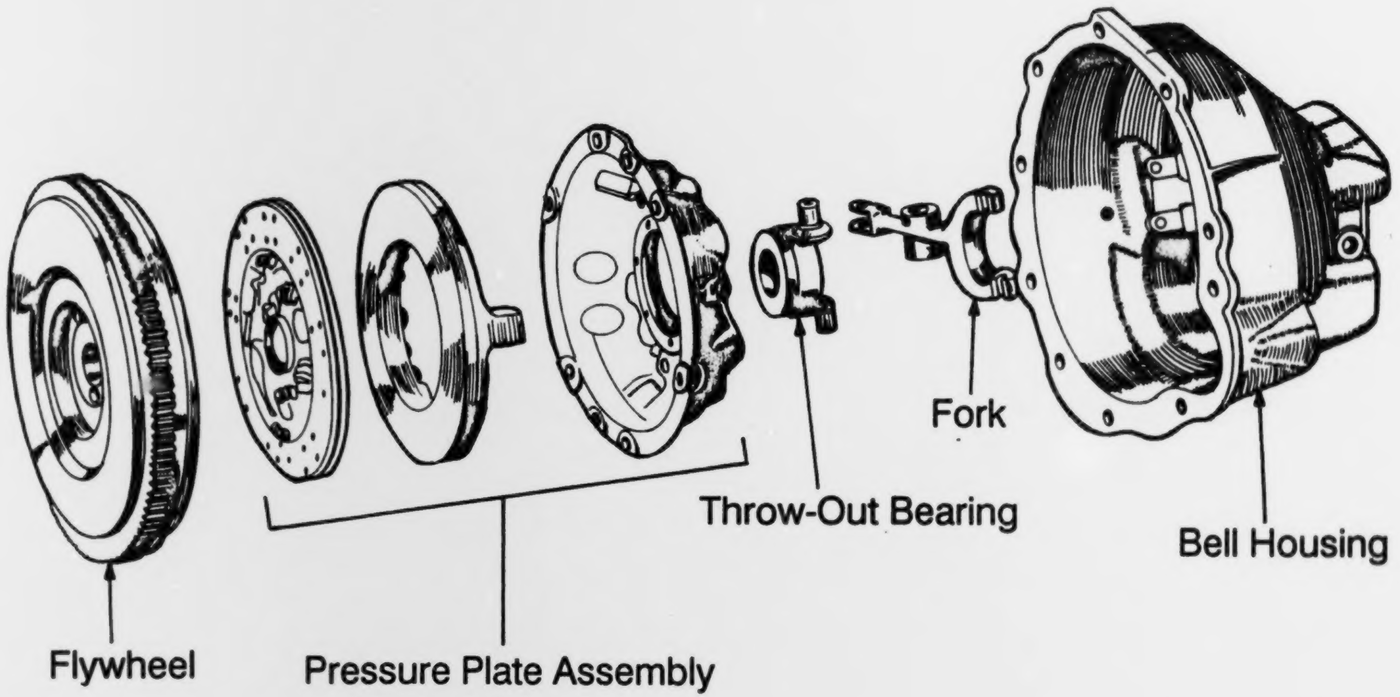
Overdrive Unit

1. Sun gear teeth for balk gear
2. Balk gear
3. Sun gear shift groove or collar
4. Pinion carrier assembly
5. Internal gear
6. Planet pinion gear
7. Roller clutch with roller cage
8. Roller clutch inner hub
9. Overdrive output shaft
10. Speedometer drive gear
11. Output shaft bearing
12. Roller clutch roller
13. Cam lever rod
14. Shift fork
15. Solenoid
16. Shift rail
17. Pawl
18. Balk ring
19. Transmission output shaft



Clutch Assembly


Flywheel
Pressure Plate Assembly
Throw-Out Bearing
Fork
Bell Housing

417

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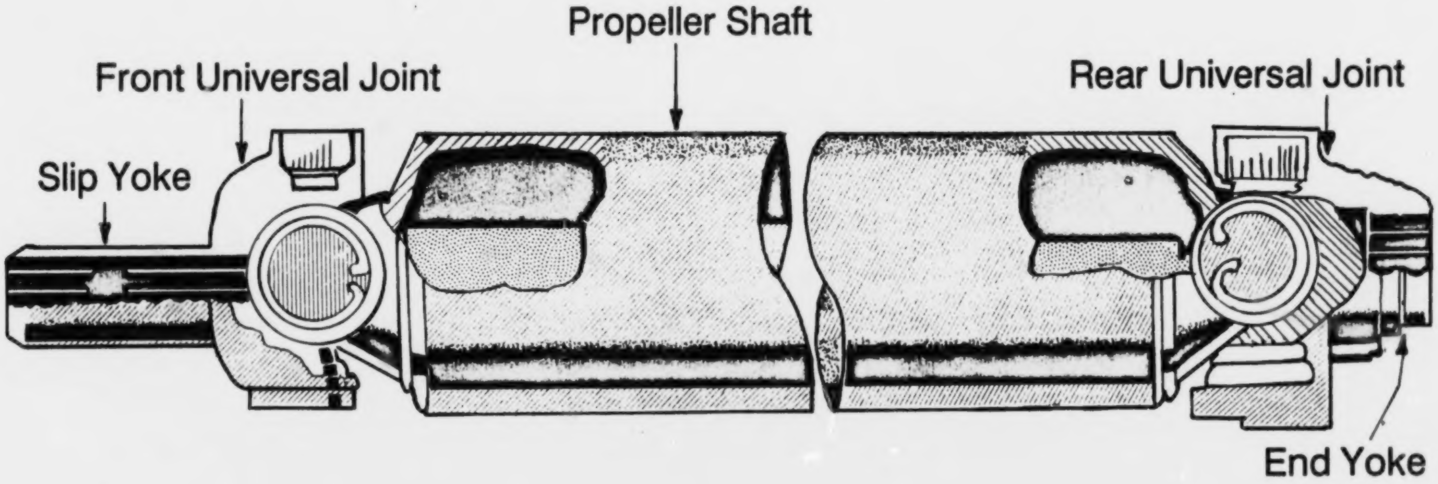
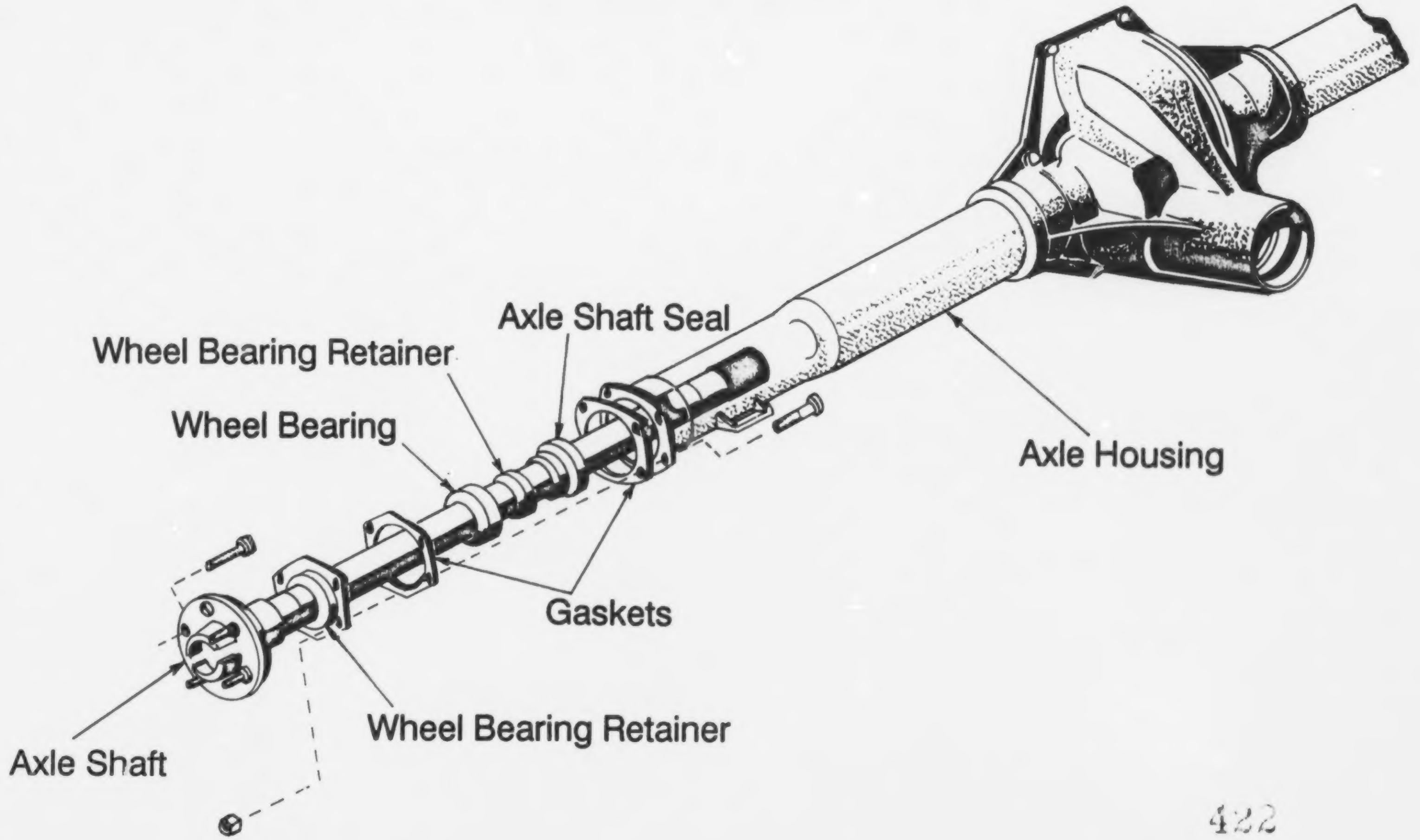
Propeller Shaft


Propeller Shaft
Front Universal Joint
Rear Universal Joint
Slip Yoke
End Yoke

Differential


Axle Shaft Seal
Wheel Bearing Retainer
Wheel Bearing
Axle Housing
Gaskets
Wheel Bearing Retainer
Axle Shaft

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ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Drive Line

TOPIC: Drive Line

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms and definitions associated with drive lines.

______a. A tube with flexible joints at each end that connects the transmission and differential

______b. An X-shaped unit that allows flexibility in the shaft between the transmission and differential

______c. The last unit of the power train that allows for the different speeds of the rear wheels when turning a corner

______d. A unit in the power train used with clutching system that allows the operator to select various gears by manually shifting

______e. A spring-loaded metal plate with a fiber coating that absorbs the shock of engine torque

______f. A metal disc bolted directly to the fly wheel that puts pressure on the clutch disc, putting the vehicle in motion.

______g. A forked device that holds the throw-out bearing in place and is connected to the clutch pedal linkage

1. Standard transmission
2. Propeller shaft
3. Clutch disc
4. Pressure plate
5. Differential
6. Universal joint
7. Clutch fork
8. Throw-out bearing
9. Axle shafts
10. Clutch pedal
11. Clutch linkage

______h. A bearing used to depress the pressure plate fingers which engages the clutch disc

______i. An adjustable metal rod located between the clutch pedal and clutch throw-out fork

______j. A device located inside the vehicle next to the steering column which allows the driver to engage or disengage the clutch

______k. Shafts that transfer the power from the differential to the rear wheels

2. Identify the components of the drive line from the list below.

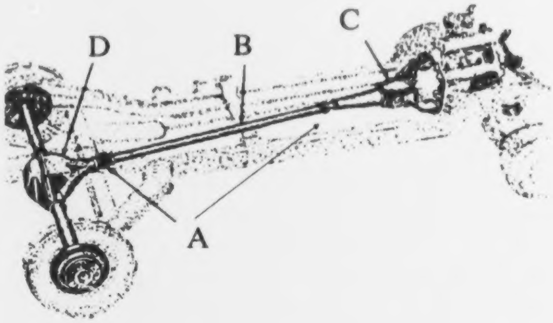
Transmission	Propeller shaft
Universal joint	Differential

a.________________

b.________________

c.________________

d.________________



3. Identify the components of the clutch assembly from the list below.

Flywheel	Throw-out bearing
Pressure plate assembly	Throw-out fork
Bell housing	

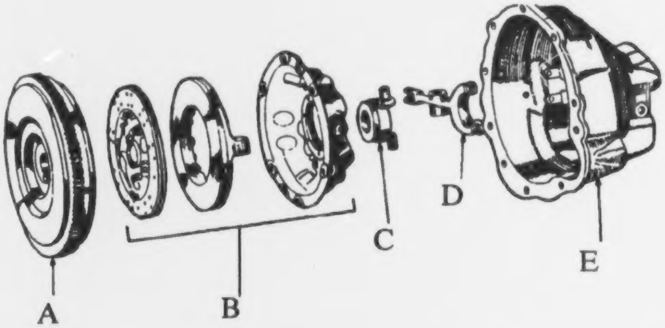
a.________________

b.________________

c.________________

d.________________

e.________________



4. Explain the ratio of standard transmission gears by circling the correct answer for each of the following:

   a. When the transmission is in first gear, the engine is turning (2, 3, 4) times as fast as the drive shaft.
   b. When the engine is turning twice as fast as the drive shaft, the transmission is in (first, second, third) gear.
   c. When the transmission is in third gear, the drive shaft will be turning (faster than, the same as, slower than) the engine.
   d. The gear ratio of the transmission to drive shaft when the transmission is in reverse is (1 to 1, 2 to 1, 2.5 to 1, 3.5 to 1).

JOB SHEET

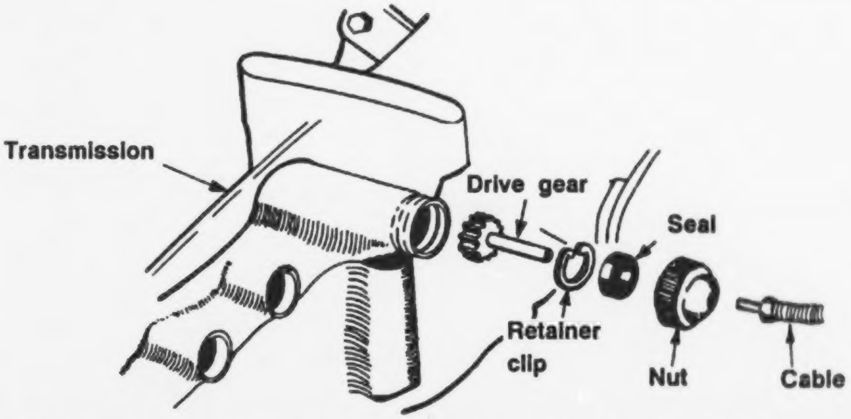
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE ________________

UNIT:	Drive Line
TOPIC:	Remove and Replace Speedometer Drive Gear
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to remove and replace a speedometer drive gear correctly.
TOOLS AND EQUIPMENT:	Slip joint pliers Snap ring pliers Socket set Hydraulic floor jack Two jack stands Creeper
GENERAL INSTRUCTIONS:	Follow procedures to remove and replace a speedometer drive gear properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

1. Raise front of car enough to place jack stands.
2. Place jack stands in a secure position.
3. Locate the speedometer cable where it enters the transmission.
4. Loosen the flange nut by turning it counterclockwise on the cable housing with the pliers.

5. Remove the cable housing.


Transmission
Drive gear
Seal
Retainer clip
Nut
Cable

6. Use the snap ring pliers to remove the snap spring holding the plastic gear in place.
7. Install the new gear in the transmission housing.
8. Replace the snap spring in the housing.
9. Replace the cable housing.
10. Tighten with common pliers.
11. Raise car with jack.
12. Remove jack stands.
13. Lower car to the floor.
14. Have instructor check work.
15. Replace tools and equipment.
16. Clean work area.

II-12-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT: Drive Line

TOPIC: Remove and Replace Drive Shaft

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the drive shaft correctly.

TOOLS AND EQUIPMENT:

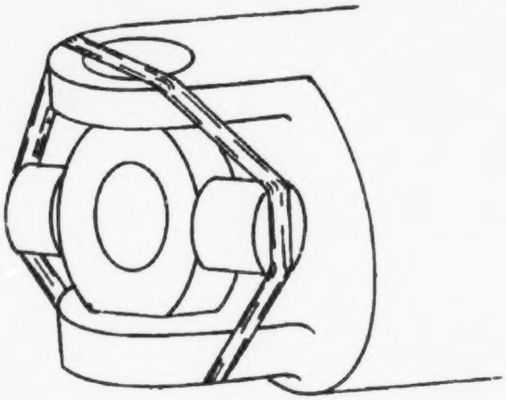
Socket set
Open-end wrench set
Hydraulic floor jack
Two jack stands
Masking tape

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the drive shaft properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise rear of car enough to place jack stands.
2. Place jack stands in a secure position.
3. Using an open-end wrench, remove nuts from the U-bolts at the rear of the drive shaft.
4. Remove the U-bolts.
   CAUTION: Hold the roller caps in place to prevent the bearings from dropping out.

5. Tape the roller caps to the cross of the universal joint.

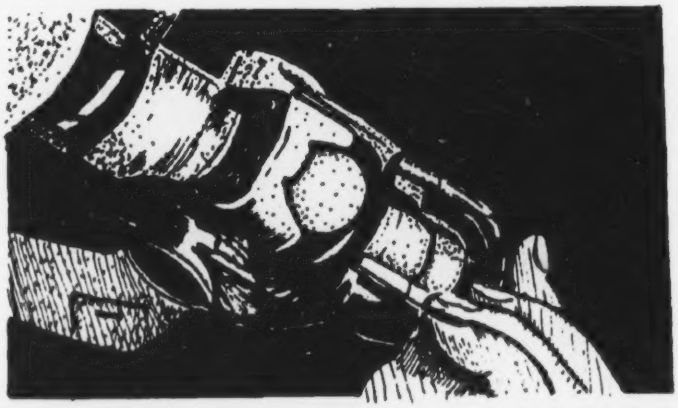


6. Pull drive shaft to rear of car to remove the shaft from the transmission spline. To prevent fluid leakage, stuff a shop towel around the splines.
   Note: *If universal joint needs to be replaced, go to Job Sheet #3.*

7. Slide new or repaired drive shaft onto transmission spline.

8. Remove tape from rear of drive shaft.
   CAUTION: Do not pull roller caps from cross.

9. Place rear of drive shaft in place on differential.



10. Install U-bolts to hold rear of drive shaft.

11. Place lockwashers and nuts on U-bolts.

12. Tighten nuts securely.

13. Raise car with jack.
14. Remove jack stands.
15. Lower car to the floor.
16. Have instructor check work.
17. Replace tools and equipment.
18. Clean work area.

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Drive Line

TOPIC: Remove and Replace Universal Joint Cross and Roller Bearings

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the universal joint cross and roller bearings correctly.

TOOLS AND EQUIPMENT:

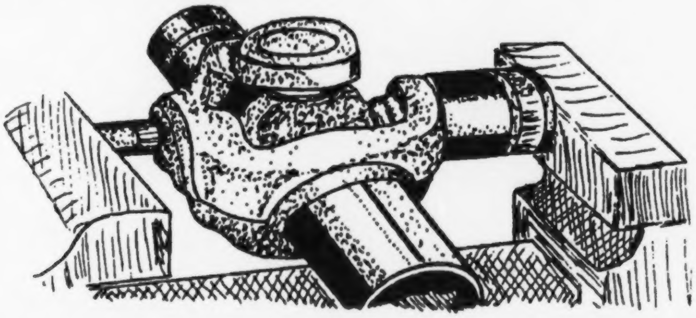
Needle nose pliers	Universal joint press
Common screwdriver	Ball peen hammer
Socket set	Grease gun

GENERAL INSTRUCTIONS: Follow procedures to remove and replace universal joint cross and roller bearings properly.

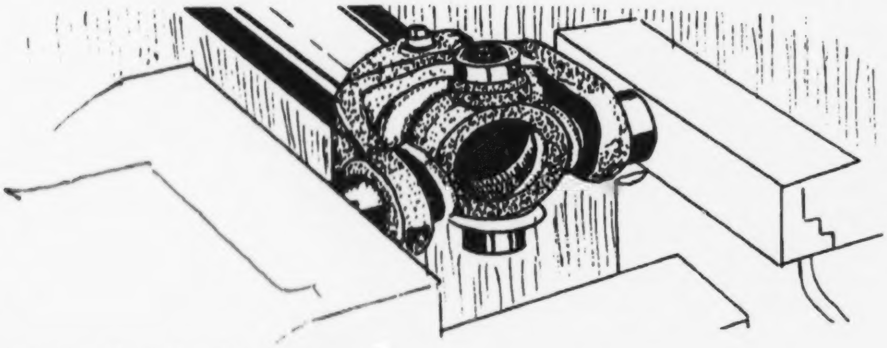
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Determine which universal joint needs the parts replaced.
2. Remove the snap rings on the outside of each roller bearing with needle nose pliers and a screwdriver.

3. Use universal joint press, or large vise.



4. Press the roller bearing free from yoke.
5. Release the vise and remove the loose bearing.
6. Place the sockets on opposite ends of the yoke.
7. Loosen the vise and remove the bearing.
8. Remove the cross by tilting it to one side.
9. Grease new roller bearings.
10. Place new cross in yoke.
11. Install new roller bearings in each side of the yoke.
12. Carefully press bearings onto the cross as they are pressed into the yoke.



13. Insert snap rings in the grooves.
14. Check the cross for freedom of movement.
15. Grease the grease fitting on the new cross with a grease gun.

16. Follow the procedures on Job Sheet #2 if the propeller shaft is to be installed.

17. Have instructor check work.

18. Replace tools and equipment.

19. Clean work area.

JOB SHEET

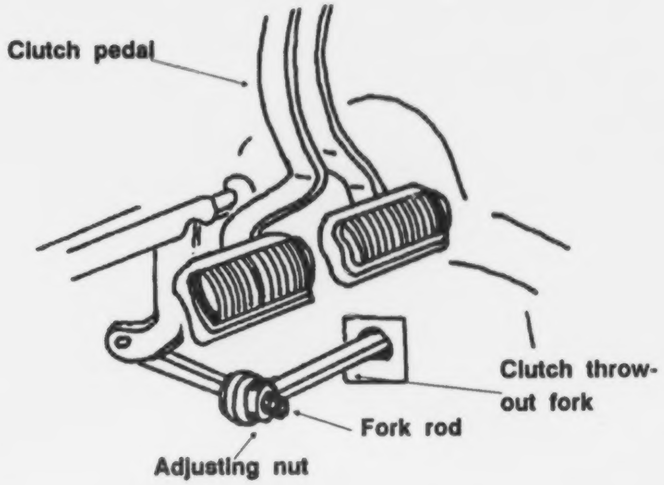
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** __________________

UNIT:	Drive Line
TOPIC:	Adjust Clutch Travel
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to adjust clutch travel correctly.
TOOLS AND EQUIPMENT:	Hydraulic floor jack Socket set Open-end wrench set Two jack stands Creeper
GENERAL INSTRUCTIONS:	Follow procedures to adjust clutch travel properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

1. Raise the front of the car enough to place jack stands.
2. Place jack stands in a secure position.
3. Locate the clutch throw-out fork adjusting nut.
   Note: *The clutch fork can be located on the side of the bell housing.*

4. Loosen the lock nut with the proper size wrench, if the fork rod has a lock nut.



5. Adjust the fork adjustment nut so that the clutch throw-out fork moves toward the rear of the car.

6. Push the clutch pedal down frequently by hand to check for proper clutch travel.
   Note: *There should be approximately 2-in. of free travel before the throw-out bearing strikes the pressure plate fingers and more pressure is required on the clutch pedal.*

7. Secure lock nut when the clutch is properly adjusted.

8. Raise car with a jack.

9. Remove jack stands.

10. Lower the car to the floor.

11. Have instructor check work.

12. Replace tools and equipment.

13. Clean work area.

II-12-JS-5

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Drive Line

TOPIC: Remove and Replace Rear Transmission Support

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the rear transmission support correctly.

TOOLS AND EQUIPMENT:

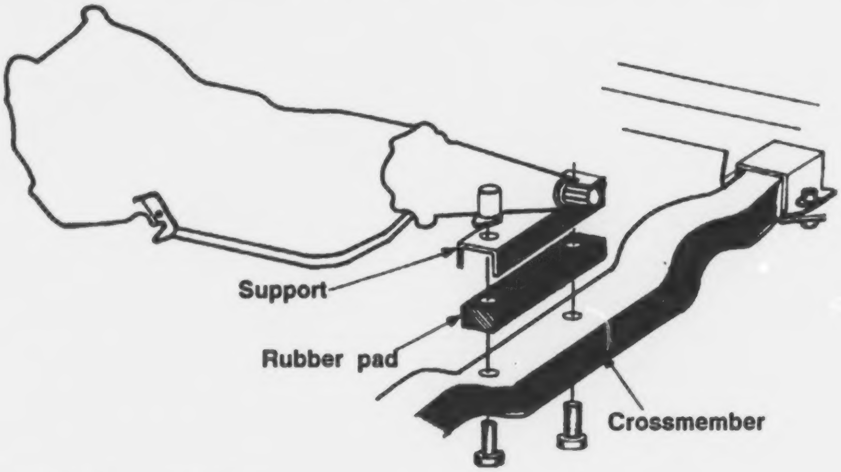
Hydraulic floor jack
Two jack stands
Socket set
Creeper
New transmission support

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the rear transmission support properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise the front of the car enough to place jack stands.
2. Place jack stands in a secure position.
3. Locate the rear transmission support on top of the crossmember and to the rear of the transmission.

4. Remove the bolts running through the crossmember and transmission support.



5. Place jack under transmission.
6. Raise transmission about 3-in. to free the support.
7. Remove the rubber support.
8. Align bolt holes in support and crossmember.
9. Lower transmission to the support.
10. Replace bolts in crossmember and support.
11. Tighten securely.
12. Raise car with a jack.
13. Remove jack stands.
14. Lower car to the floor.
15. Have instructor check work.
16. Replace tools and equipment.
17. Clean work area.

II-12-JS-6

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Drive Line

TOPIC: Replace Rear Transmission Seal

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the rear transmission seal correctly.

TOOLS AND EQUIPMENT:

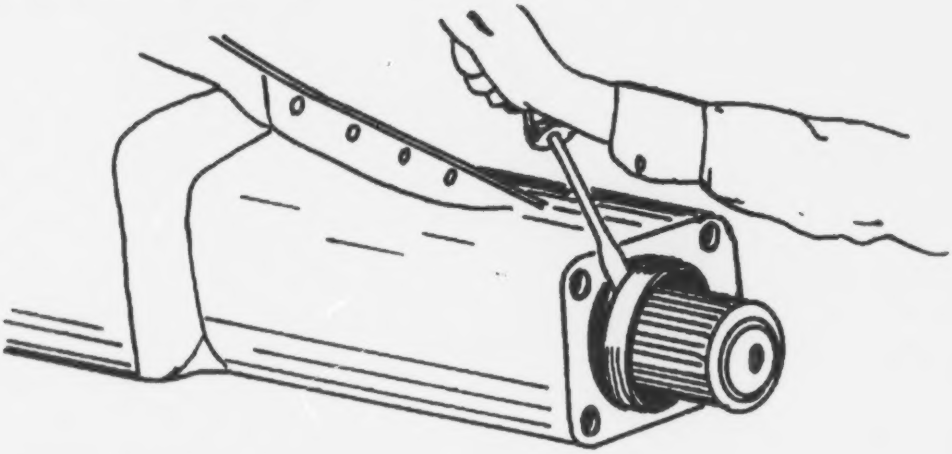
Hydraulic floor jack
Two jack stands
Creeper
Open-end wrench
Rubber mallet
Common screwdriver
Socket set
Masking tape
Rear transmission seal

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the rear transmission seal properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise rear of car enough to place jack stands.
2. Place jack stands in a secure position.
3. Remove rear universal joint U-bolts.
4. Tape the roller bearings in place with masking tape.
5. Remove drive shaft by pulling it to the rear of the car.

6. Insert screwdriver under lip of rear transmission seal and pry out.
7. Pry on seal until removed.



8. Install new seal into housing.
9. Tap gently around the seal until it is flush with the cone housing.
10. Replace drive shaft onto transmission spline.
11. Remove tape from roller bearings.
12. Place rear universal joint in place on differential yoke.
13. Replace U-bolts.
14. Tighten securely.
15. Raise car with a jack.
16. Remove jack stands.
17. Lower car to the floor.
18. Have instructor check work.
19. Replace tools and equipment.
20. Clean work area.

II-12-JS-7

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ________________

UNIT: Drive Line

TOPIC: Remove and Replace Rear Axle Bearing

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(A), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to remove and replace the rear axle bearing correctly.

TOOLS AND EQUIPMENT:

- Socket set
- Slide hammer puller
- Hydraulic floor jack
- Jack stand
- New rear axle bearing
- Lug wrench

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the rear axle bearing properly.

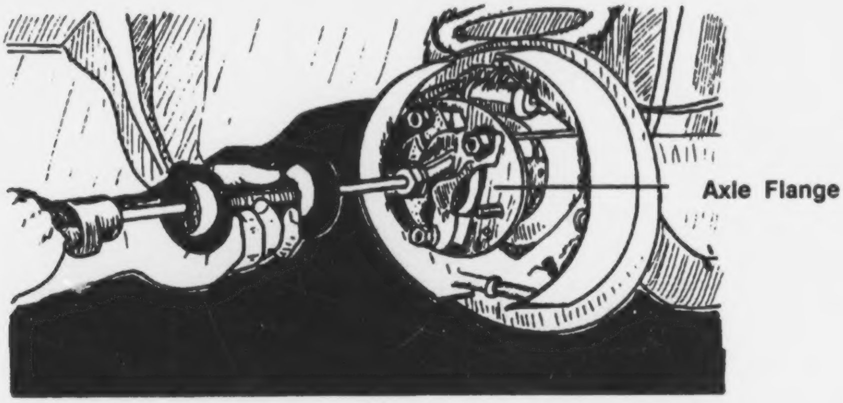
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Raise the rear wheel enough to place jack stand.
2. Place jack stand in a secure position.
3. Remove hub cap.
4. Remove wheel.
5. Rotate axle flange until a bolt head appears in the hole in the axle flange.
6. Remove the retainer bolt using the correct socket with the socket wrench.

7. Remove each of the retainer bolts through the hole in the flange.

8. Connect the slide hammer to the axle flange lug bolts.
CAUTION: Do not disrupt brake components.

9. Remove the rear axle by using the slide hammer puller.
CAUTION: Keep your fingers clear of the sliding hammer.



10. Cut or press the old bearing off of the axle.

11. Press new bearing on the axle.
Note: *The grease seal should be replaced if necessary.*

12. Replace axle in differential housing.

13. Replace retainer bolts and nuts.

14. Tighten the nuts and bolts securely.

15. Replace the wheel.

16. Replace the hub cap.

17. Raise car with a jack.

19. Remove jack stand.

19. Lower car to the floor.

20. Have instructor check work.

21. Replace tools and equipment.

22. Clean work area.

II-13-IS

STUDENT INFORMATION SHEET

MINOR AUTOMOTIVE MAINTENANCE

UNIT: Cleaning the Car

TOPIC: Cleaning the Car

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to identify cleaning materials and equipment, clean interior and exterior of the car and wax surfaces.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to clean interior, exterior, upholstery, vacuum the interior and wax the exterior.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with wheels and tires include oral and written communications and reading concepts.*

Cleaning the Car

The process of cleaning the car is very important. When you drive your car or try to trade it in or sell it, it will be judged on its appearance as well as the performance.

The main reason for washing your car often and keeping a good coat of wax on it is not only to make it look good, but to keep salt, mud and chemical-laden dust and dirt off that will create rust and accelerate the deterioration of the paint. If you do not have access to a hose or area to clean your car, use the coin-operated car wash.

Washing the Car

Never wipe or dust the car with a dry cloth. This will scratch the paint.

Never wash the car in the hot sun; this can ruin the finish.

Use cold or lukewarm water and a hose. The hose with a spray nozzle can project a stream forceful enough to break loose mud, bird droppings, and other items that stick to the exterior. Don't use a bucket because dirt is transferred to the water with the rag or sponge where it can scratch or streak the finish.

Always wash the car from the top down. Be sure to wash all the corners where dirt can collect and rust can form.

Wash one section at a time, hose it down, soap it and rinse it off. When the entire car is washed, hose it all down again to be sure all the soap is washed away. Then dry the car with a chamois or terry cloth towel to prevent water spotting that can mar the cars surface.

While using commercial products use caution. Always read and follow directions on the package or container. Some products can damage or cause skin irritation.

Cleaning Windows

The products used in your home can be used to spray on windows. Use a lint free rag or sturdy paper towels to avoid scratching the glass. Use vertical strokes on the outside and horizontal strokes on the inside of each window. This way you can see at a glance if you have streaks on the side you are cleaning. Always lift the windshield wipers and clean under them. A dirty blade can scratch the glass.

Chrome and Metal Trim

Use a special type wax and cleaner designed for chrome bumpers and metal surfaces because they require more protection than painted surfaces. Chrome polish will clean the metal without scratching it, and will retard rust and leave a shining surface.

Tires

Use a mild soap or dish detergent to remove grease and dirt. A brush or scouring pad will help clean the tires. Tires can be sprayed after cleaning with a silicone lubricant to help preserve the rubber.

Vinyl Tops

Vinyl and convertible tops can usually be cleaned with dish detergent or a mild soap and water easily. Use a soft brush to brush in circles. This will help clean crevices. Rinse often to wash away dirt.

Waxing the Car

If water does not bead on the car when it rains or when you hose it down, it needs to be waxed. The car finish needs to be waxed at least twice a year. This will protect the finish from the weather and is important to keep the car rust free and looking good. Always wash the car before you wax the finish. Make sure the wax and cleaner are free of abrasives.

Soft waxes without cleaners are good for sealing the surface. You can wipe them on, let it dry to a haze and then wipe away.

Harder paste wax provides the most protection. These waxes are harder to apply and require rubbing and buffing to acquire a high gloss shine.

Upholstery and Carpeting

Household products can be used to clean the car's interior. Avoid using a large amount of water. If fabrics get too wet around buttons or attachments, rust or deterioration can result. If fabric is too wet, use a portable hair dryer to dry the padding and fabric. The best product for fabrics and rugs are spray types that turn to powder and are removed by vacuuming.

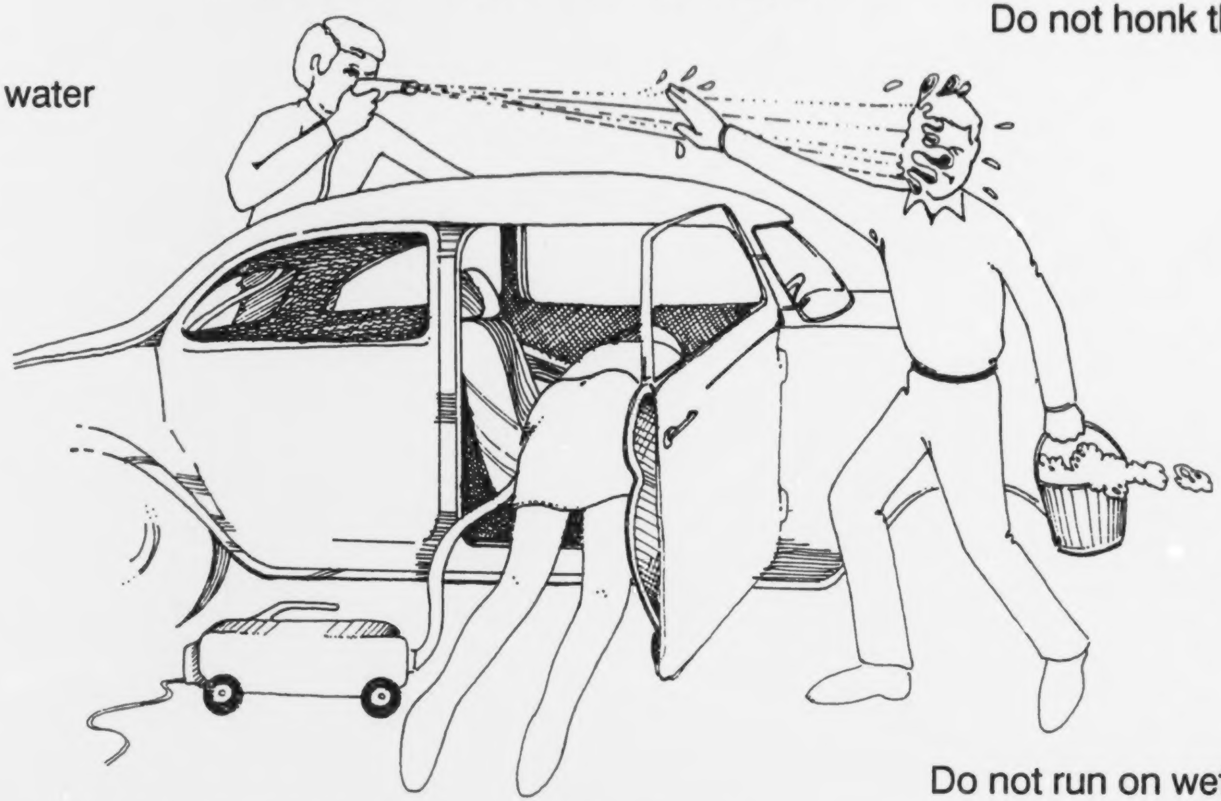
Leather seats need to be kept clean and moisturized, or they will dry out, crack and age prematurely. Use a high quality product like saddle soap. Neatsfoot oil will soften, lubricate, waterproof, restore and preserve leather that has been cleaned.

Cleaning the Car

Watch out for buckets or other objects

Do not honk the horn

Do not spray water



Do not run on wet floors

Be careful using electrical appliances around water

TM-1

II-13-AS

ASSIGNMENT SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________ **DATE** ______________

UNIT: Cleaning the Car

TOPIC: Unit Test

DIRECTIONS: Read and answer the following questions by circling **T** for true or **F** for false.

T F 1. The chamois is used to clean dust from car finish.

T F 2. The instructions should be read each time cleaners are used.

T F 3. A soft towel is used when cleaning the tires.

T F 4. The chamois is used to remove water spots.

T F 5. Using a dry cloth to wipe dust from a car will scratch the finish.

T F 6. Washing the car in the hot sun will not damage the finish.

T F 7. A bucket, sponge and warm water should be used to wash the car.

T F 8. Some cleaners will cause skin irritation.

T F 9. You should not clean under the windshield wipers.

T F 10. Chrome polish will not retard rust.

T F 11. A silicon lubricant will help preserve the rubber on tires.

T F 12. Vinyl tops are cleaned with a soft rag.

T F 13. Mild soap or detergent should be used to clean vinyl tops.

T F 14. A hard paste wax gives the best protection for a finish on the car.

T F 15. Saddle soap is used to clean leather seats.

II-13-JS-1

JOB SHEET

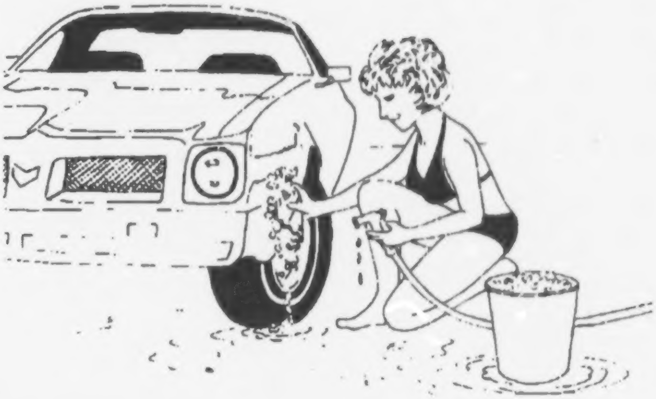
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT:	Cleaning the Car
TOPIC:	Washing the Car Exterior
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to wash the car exterior correctly.
TOOLS AND EQUIPMENT:	Bucket of warm water Mild detergent Water hose Sponge or rag Chamois or terry towel Window cleaner Paper towels
GENERAL INSTRUCTIONS:	Follow procedures to wash the car exterior properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's shop manual for specifications. **Note:** *Follow all safety rules.*

1. Spray the car with the water hose until all surfaces are wet.
2. Mix about one cup of detergent in the warm water.
3. Apply the detergent solution to the car surface.
4. Rub car finish as necessary to remove dirt or stains.

5. Wash one panel or section at a time.



6. Rinse each panel washed before going to the next panel.

7. Continue this process until the exterior surface is clean.

8. Wash and rinse the wheels.

9. Rinse the chamois.

10. Wipe excess water from the car with the chamois.
Note: *Squeeze the water from the chamois when it becomes saturated.*

11. Clean the car windows with the cleaner and dry with paper towels.

12. Have instructor check work.

13. Replace tools and equipment.

14 Clean work area.

II-13-JS-2

JOB SHEET

MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ DATE __________________

UNIT: Cleaning the Car

TOPIC: Wax the Car Surface

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to wax the car surface correctly.

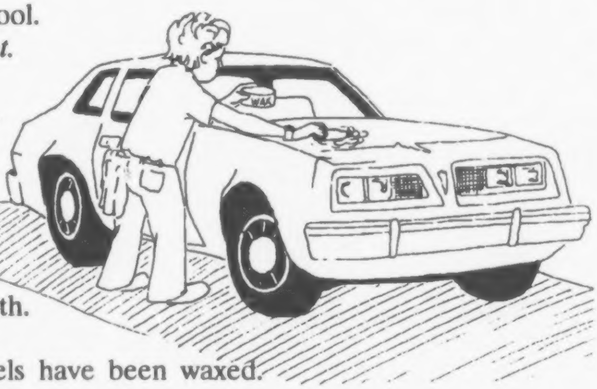
TOOLS AND EQUIPMENT:

Car wax
Applicator cloth
Polish cloth
Chrome cleaner

GENERAL INSTRUCTIONS: Follow procedures to wax the car surface properly.

PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Clean surfaces of car, if not already cleaned.
2. Check to see if surface of car is cool.
   Note: *Do not wax in direct sunlight.*
3. Apply wax to one panel at a time.
4. Allow wax to dry.
   CAUTION: If wax dries too long, it will be hard to remove.
5. Wipe dried wax off with a soft cloth.
6. Continue this process until all panels have been waxed.



7. Clean chrome on car with chrome cleaner.
   Note: *If chrome cleaner is not available, wax the chrome surfaces.*

8. Have instructor check work.

9. Replace tools and equipment.

10. Clean work area.

JOB SHEET
MINOR AUTOMOTIVE MAINTENANCE

NAME ______________________________ **DATE** ____________________

UNIT: Cleaning the Car

TOPIC: Clean and Vacuum the Interior

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(E), (ddd)(1)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to clean and vacuum the interior correctly.

TOOLS AND EQUIPMENT:

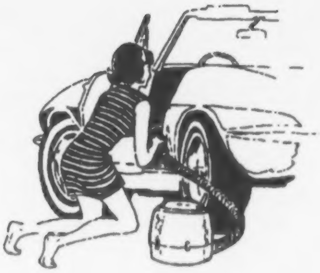
Clean cloth or rag
Whisk broom
Upholstery cleaner
Vacuum cleaner
Spot remover

GENERAL INSTRUCTIONS: Follow procedures to clean and vacuum the interior properly.

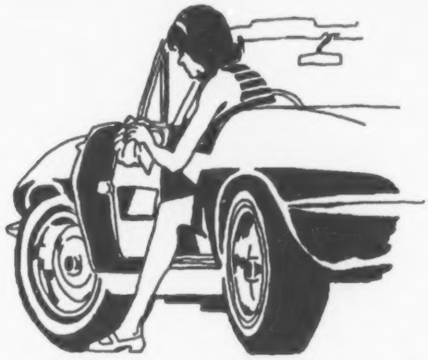
PROCEDURES AND/OR TASKS: Check manufacturer's shop manual for specifications.
Note: *Follow all safety rules.*

1. Dust the upholstery and carpet with the whisk broom to loosen any dirt or mud.
2. Empty ash trays and litter bags.
3. Vacuum seams and corners of upholstery.

4. Vacuum all floor area.



5. Apply upholstery cleaner.
   Note: *Read manufacturer's instructions on container.*



6. Apply spot remover on any area not cleaned with upholstery cleaner.

7. Empty vacuum cleaner bag.

8. Have instructor check work.

9. Replace tools and equipment.

10. Clean work area.

STUDENT INFORMATION SHEET
SMALL ENGINE REPAIR

UNIT:	Engine Principles
TOPIC	Engine Parts and How They Work
ESSENTIAL ELEMENT(S):	(a)4, (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B)
UNIT OBJECTION:	After completing this unit, the student(s) will be able to identify and discuss the four-cycle and the two-cycle engine components, and demonstrate the difference between engines.
SPECIFIC OBJECTIVE(S):	After completing this information sheet, the student(s) will be able to explain the difference between the external and internal combustion engines and the components of the small engines.
BASIC ACADEMIC SKILLS APPLICATIONS:	*Basic academic skills used with engine principles include oral and written communications, and the application of reading concepts and skills.*

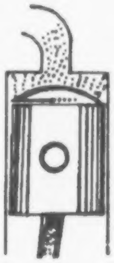
Engine Principles

The Parts of the Engine and How They Work

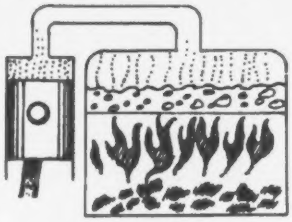
The purpose of the combustion engine is to change raw materials such as gasoline into mechanical power to do the many work-related jobs needed by man.

Types of combustion engines

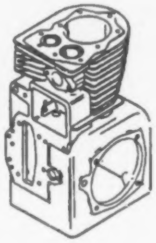
Internal-combustion engine is a machine used to burn raw materials within itself



External-combustion engine—A machine designed to accept the pressure of raw materials being burned in another container and then forced into the engine



The parts of the gasoline engine and their purpose

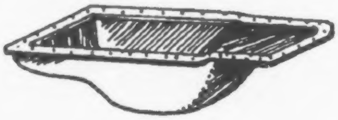


Block

- Main framework of the piston engine
- Houses internal parts
- Provides a place to mount external parts

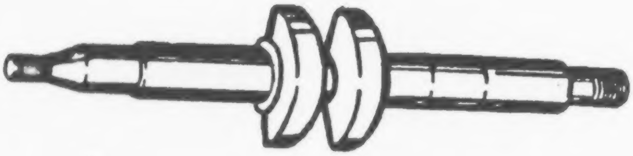
Crankcase

- The housing within which the crankshaft and other engine parts operate
- Contains the oil for lubrication of the engine
- Also known as oil pan



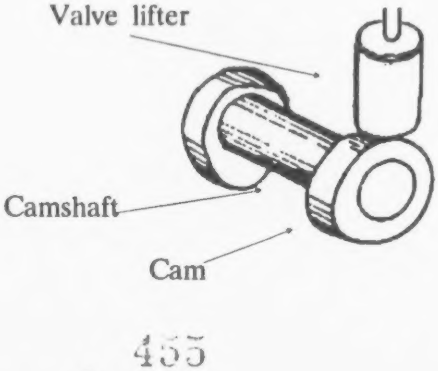
Crankshaft

- The main shaft running through the engine
- Converts the up and down motion of the piston to usable rotary power



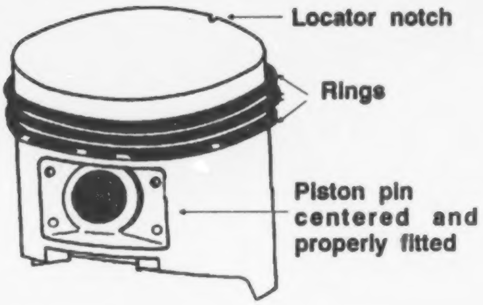
Camshaft

- Contains lobes or cams
- Opens engine valves



Piston

- A round part closed on one end
- Installed in a cylinder hole
- Attached to a connecting rod
- Transfers force of explosion to a connecting rod


Locator notch
Rings
Piston pin centered and properly fitted

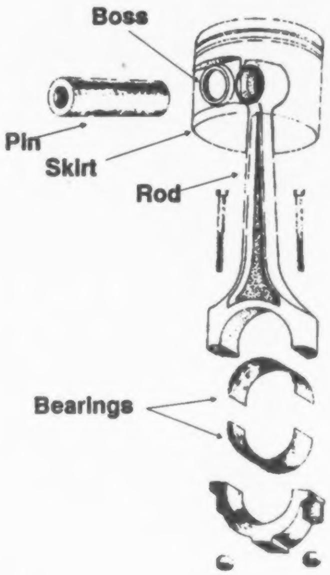
Ring—A flexible piece of metal used to seal the piston to the cylinder walls during the power and compression stroke.

Piston pin

- The journal for the bearing in the small end of the connecting rod
- Connects the rod to the piston
- Also known as a "wrist pin"

Piston boss—The part of the piston through which the piston pin is inserted

Piston skirt—The lower part of the piston


Boss
Pin
Skirt
Rod
Bearings

Connecting rod

- A shaft connecting the piston to the crankshaft
- Transfers the force of the explosion from the piston to the crankshaft

Bearing

- A replaceable, load-carrying part
- Cuts down on friction and wear
- Main and insert bearings are used on the crankshaft

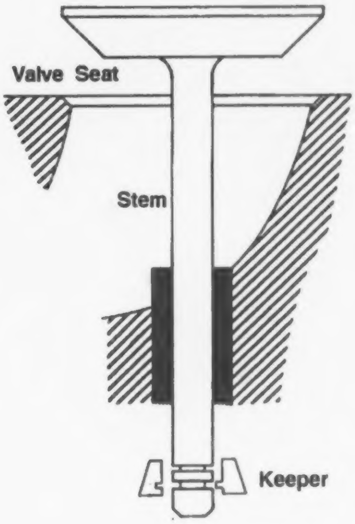
Valve

- A device used to start or stop the flow of the air-gas mixture
- Allows fuel to come into the cylinder
- Allows burned fuel to exhaust out of the cylinder

Valve face—The part of the valve that comes in contact with the valve seat.

Keeper—Piece of metal used to secure the valve spring onto the valve

Valve seat—Area on the engine with which the valve face comes into contact



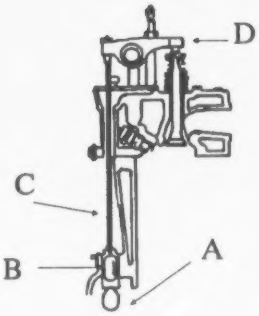
Purpose of the parts of the valve train.

A. Camshaft—The lobes lift the hydraulic lifters

B. Lifter—Raises the push rods

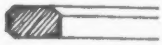
C. Push rod—Pushes the rocker arm

D. Rocker arm—Pushes the valve open

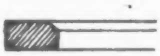


Purpose of the types of rings

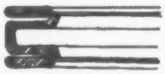
Compression ring—Seals the piston within the cylinder and prevents explosion "blow by"



Wiper ring—Wipes the oil off the cylinder wall back into the oil pan on the downward movement of the piston

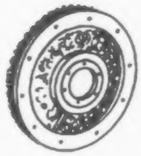


Oil ring—Applies oil to the cylinder wall on the upward stroke of the piston



Purposes of the flywheel

- Acts as a balance to smooth the engine
- Provides a starter gear
- Serves as necessary force to carry the engine to the next stroke



Elements necessary to cause an explosion in the cylinder

Fire—The spark plug produces a spark to ignite fuel

Fuel—A combustible substance, usually gasoline

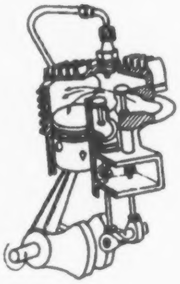
Air—Supports combustion of substance

Conditions necessary for a gasoline engine to work

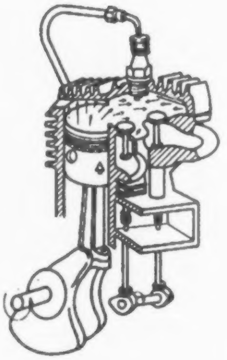
- Some method of cranking the engine is used to start it turning
- The correct amount of fuel and air is mixed
- The fuel and air mixture is pulled into the cylinder through the intake valve
- The spark plug fires near the top of the compression stroke, which explodes the gases and pushes the piston downward.

The four-stroke cycles of the gasoline engine

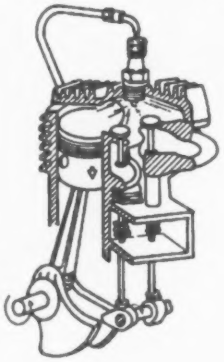
Intake stroke—As the piston moves downward, the intake valves open to be filled with the correct fuel air mixture.



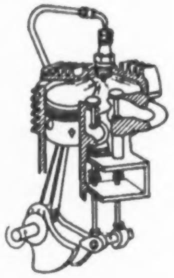
Compression stroke—As the piston moves upward, the intake valves close and the fuel-air mixture is compressed.



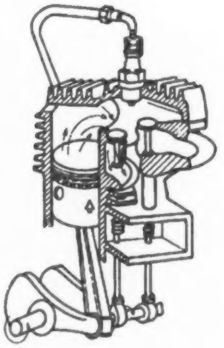
Ignition—This action is **not** considered a stroke, but an event that occurs, causing the fuel-air mixture to explode.



Power stroke—The piston begins a downward motion, being forced by expanding burning gases.



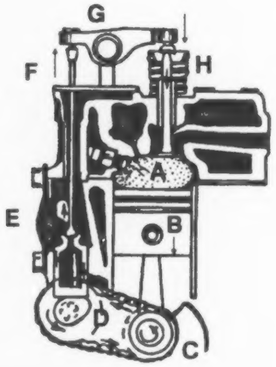
Exhaust stroke—The piston moves upward as the exhaust valve opens, allowing the burned gases to be forced from the cylinder.



Events in a power sequence

Note: *Follow sequence on drawing.*

- A. Explosion over piston.
- B. Piston drives rod.
- C. Rod drives crankshaft.
- D. Crankshaft drives the camshaft.
- E. Camshaft drives the lifter.
- F. Lifter raises the push rod.
- G. Push rod drives the rocker arm.
- H. Rocker arm opens valve.



Terms and Definitions

Camshaft is a shaft with lobes used to open the engine's valves at the proper time.

Compression ring is the piston ring used to seal compression pressures inside the combustion chamber.

Connecting rod is the engine part that connects the piston to the crankshaft.

Connecting rod bearing is a device used between the connecting rod and the crankshaft to reduce friction and wear.

Cylinder is a tube in which the piston rides.

Cylinder head is a large casting bolted to the top of the engine containing the combustion chamber.

Exhaust ports are the passages used to route burned gases out from the cylinder.

Exhaust valve is used to control flow of burned exhaust gases from the cylinder.

Flywheel is used to store energy and smooth out engine operation.

Four-stroke-cycle engine generates power using four strokes of a piston.

Intake ports are the passages in the cylinder head used to route the flow of air and fuel into the cylinder.

Intake stroke is the stroke of the four-stroke-cycle engine during which the air and fuel enter the engine.

Intake valve controls the flow of air and fuel into the engine.

Lobe is a raised bump on the camshaft used to lift a valve.

Piston is a round metal part attached to the connecting rod which slides up and down in the cylinder.

Piston pin is used to attach the piston to the connecting rod.

Piston ring is a expanding sealing ring placed in a groove around the piston.

Valve is a device for opening and closing a port.

Valve guide is a part to support and guide the valve.

Valve lifter rides on the cam and pushes open the valve.

Valve spring is a coil spring used to close the valve.

Valve train is the part of an engine that opens and the closes the passageways for the intake of air and fuel as well as the exhausting of burned gases.

Fundamentals of Two-Stroke-Cycle Engine

The parts of a two-stroke and the four-stroke cycle engine are basically the same except the two-cycle engine has no valve train. There are two holes or ports in the cylinder.

One is called the exhaust port because it removes the burned fuel mixture. The other is the intake port, which lets in the fresh air and fuel mixture.

Operation of the Two-Cycle Engine

As the piston moves up in the cylinder, the space below the piston gets larger and creates a vacuum in the crankcase. The air and fuel mixture is then pulled into the crankcase through the reed valve. The intake and exhaust ports are covered by the piston at the same time, trapping the fuel mixture above the piston. As the piston compresses the mixture in the combustion chamber, near the top of the upward stroke, the mixture is ignited by a spark and begins to burn, causing an explosion. The expanding gases force the piston down and, in turn, the piston gives its power to the camshaft. As the piston moves down, the crankcase becomes smaller. The air and fuel mixure in the crankcase is compressed, and when the piston moves down far enough in the cylinder, the exhaust port is uncovered and the burned fuel goes out the exhaust port. When the piston reaches the bottom of its stroke, the intake port is uncovered and the air-fuel mixture trapped in the crankcase flows through the transfer port into the cylinder. As the piston again moves up, the mixture is trapped and the cycle starts over again.

The basic components of a two-stroke-cycle engine are shown on TM-11.

Terms and Definitions

Bypass port is the passageway between the crankcase and combustion chamber in a two-stroke engine.

Loop scavenged is the type of two-stroke engine in which the air-fuel mixture loops through the bores in the piston skirt.

Reed valve controls the flow of air-fuel mixture into the crankcase.

Rotary valve is attached to the crankshaft and controls the flow of air and fuel into the crankcase.

Transfer port is the same as the bypass port.

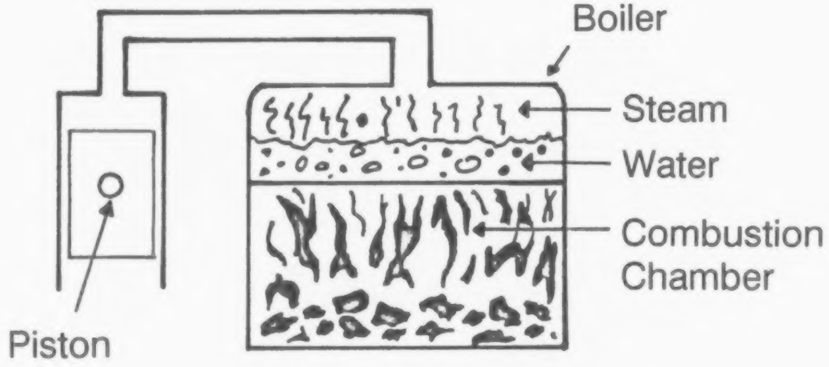
Two-stroke-cycle engine develops power in two piston strokes or one crankshaft revolution.

Crankcase pressure is built up in the crankcase by the downward motion of the piston.

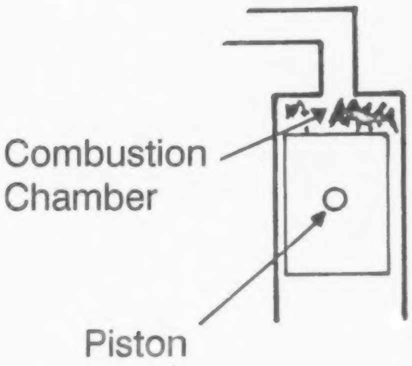
Crankcase vacuum is created when the piston moves upward in the cylinder.

Expansion chamber is an exhaust system designed to produce the maximum horsepower at a specific RPM range.

Internal and External Combustion


Boiler
Steam
Water
Combustion Chamber
Piston

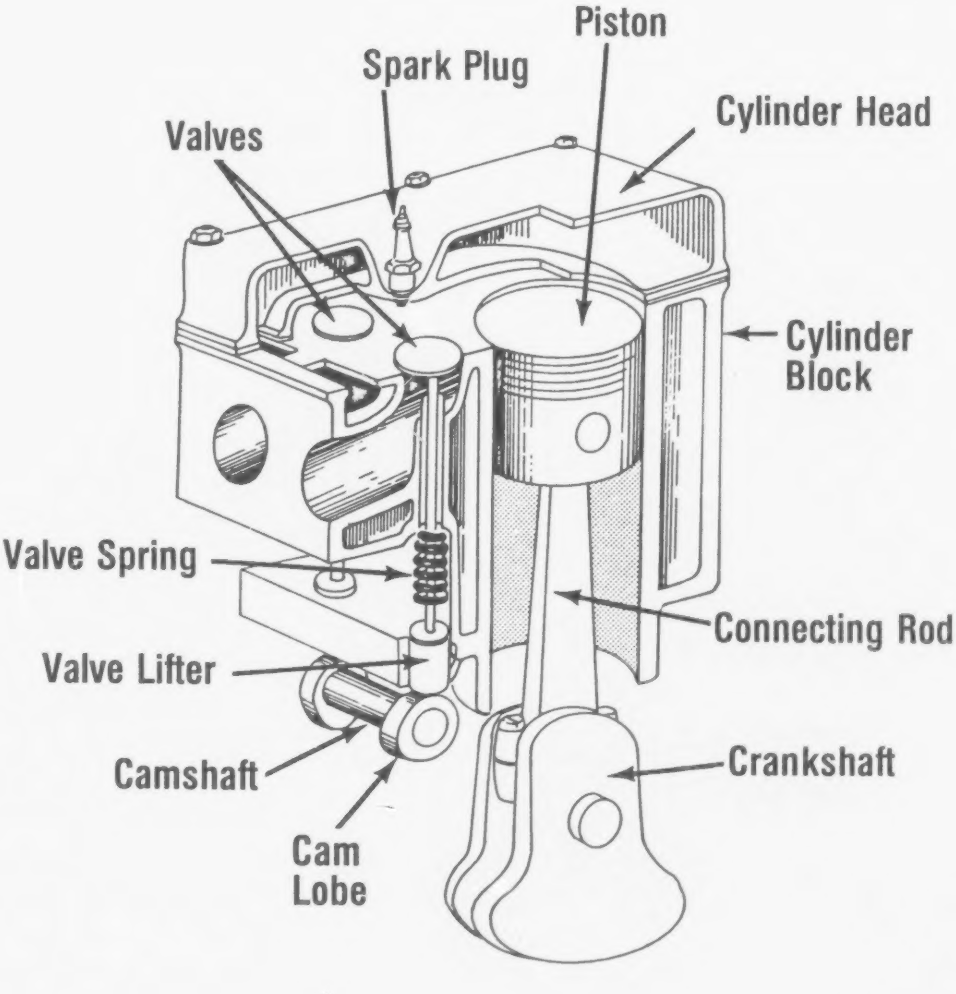
External Combustion


Combustion Chamber
Piston

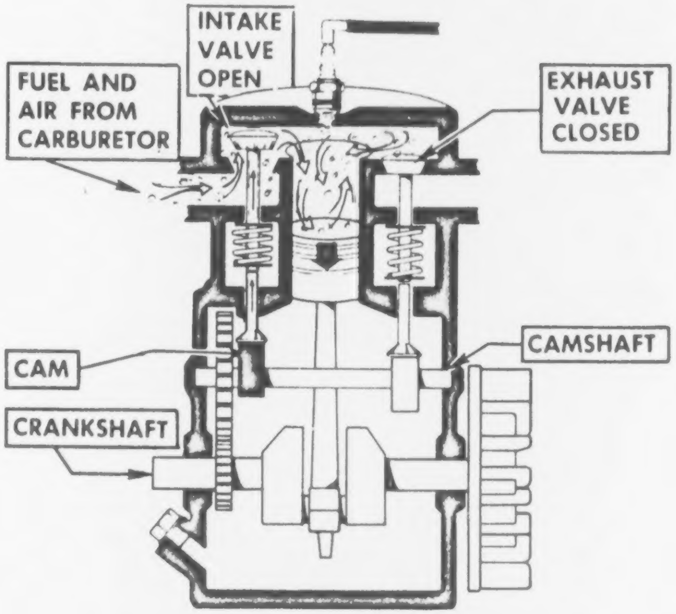
Internal Combustion Engine

TM-1

Components of a Four-Stroke Cycle Engine

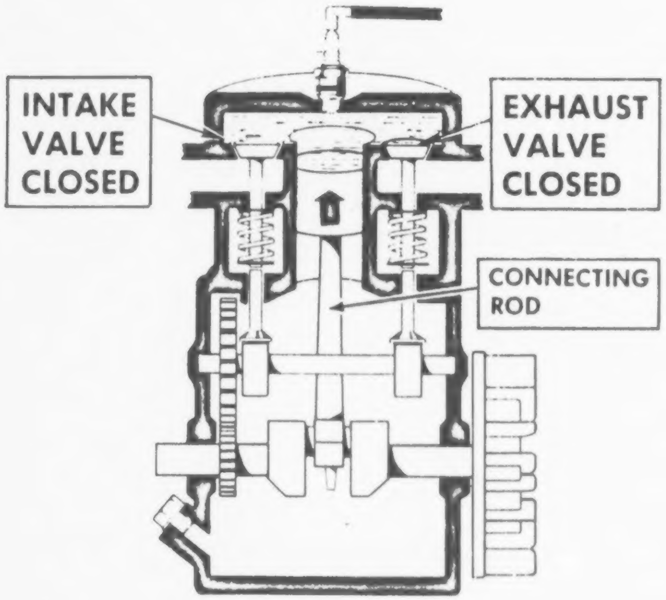

Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam Lobe

Four-Stroke Cycle


FUEL AND AIR FROM CARBURETOR
INTAKE VALVE OPEN
EXHAUST VALVE CLOSED
CAM
CAMSHAFT
CRANKSHAFT

Piston Intake Stroke

465

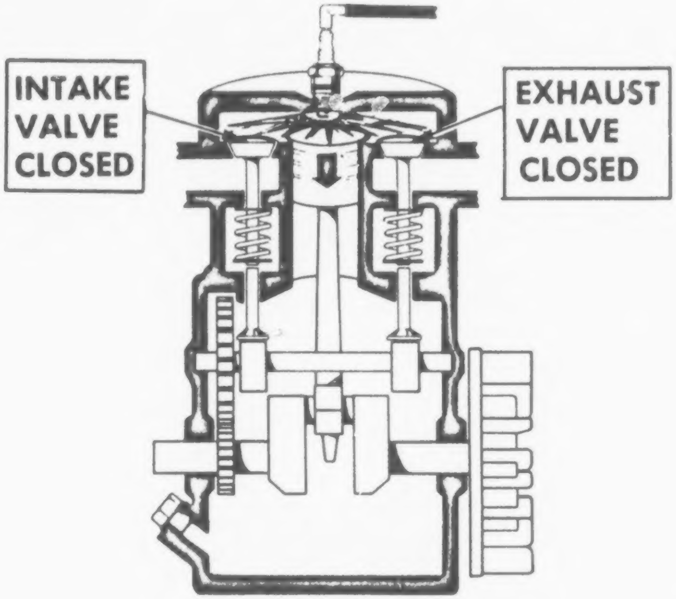

INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED
CONNECTING ROD

Piston Compression Stroke

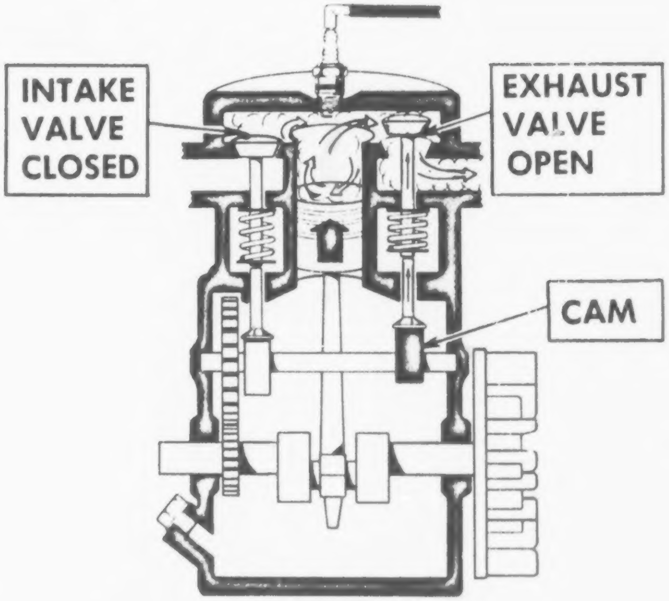
466

TM-3

Four-Stroke Cycle


INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED

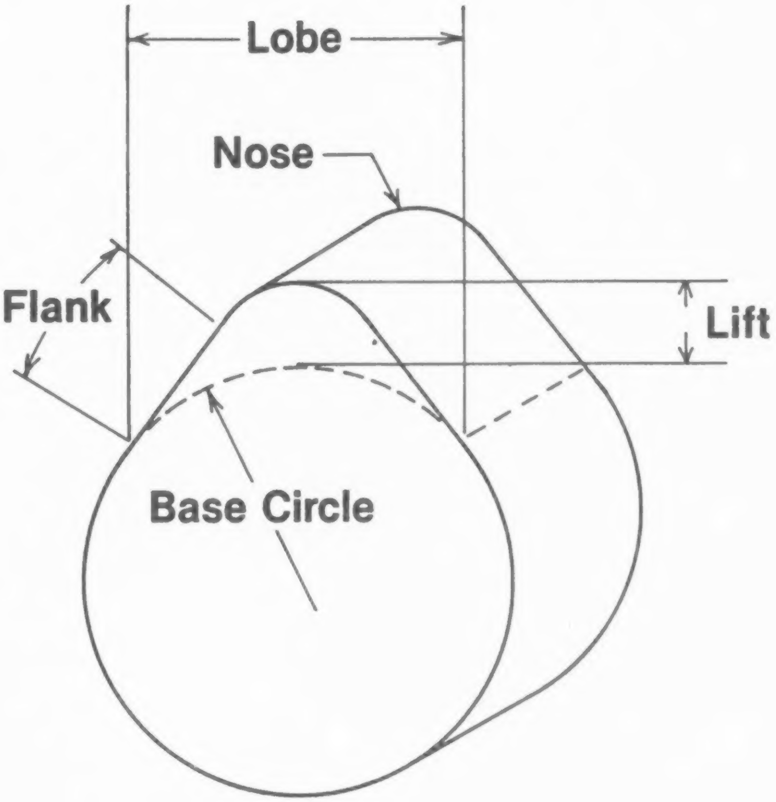
Piston Power Stroke


INTAKE VALVE CLOSED
EXHAUST VALVE OPEN
CAM

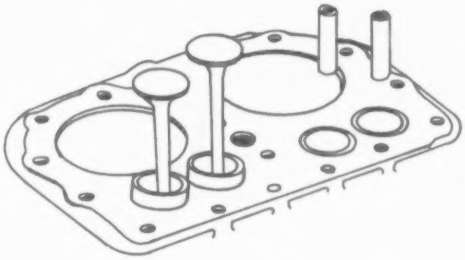
Piston Exhaust Stroke

TM-4

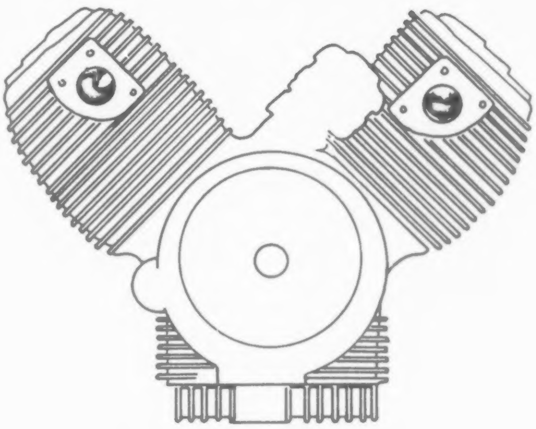
Cam Lobe Contour Design


Lobe
Nose
Flank
Lift
Base Circle

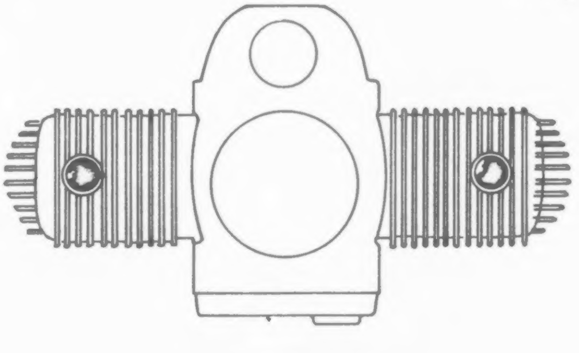
Engine Designs



In-Line



V-Type

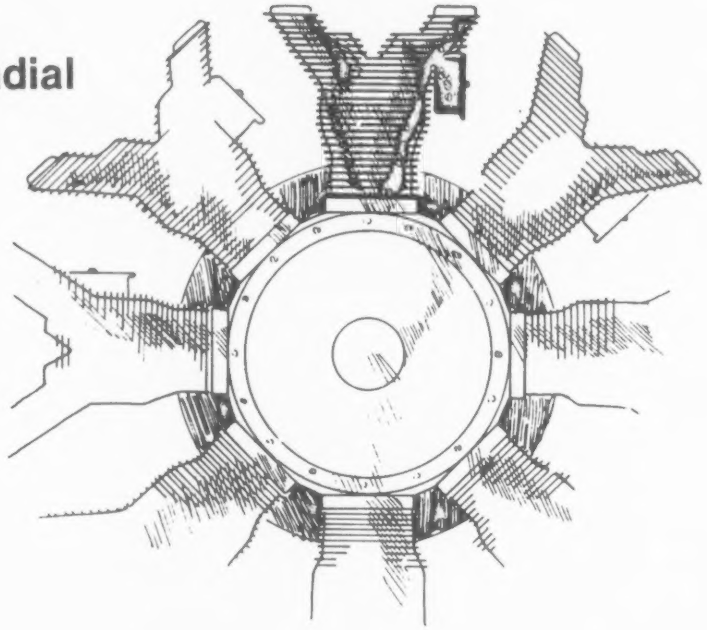


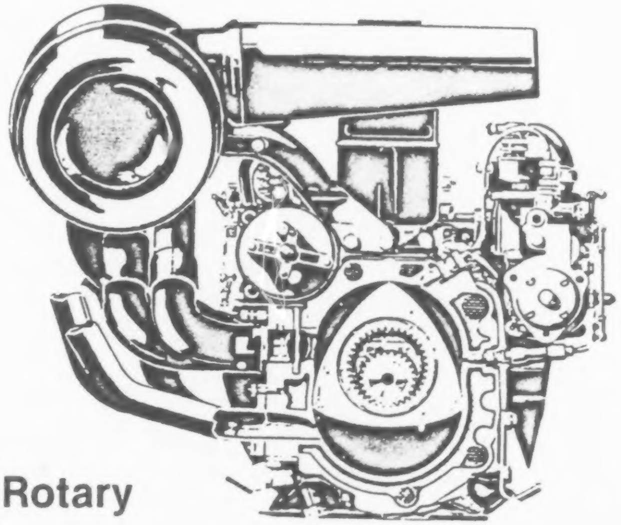
Opposed

Engine Designs

(Continued)

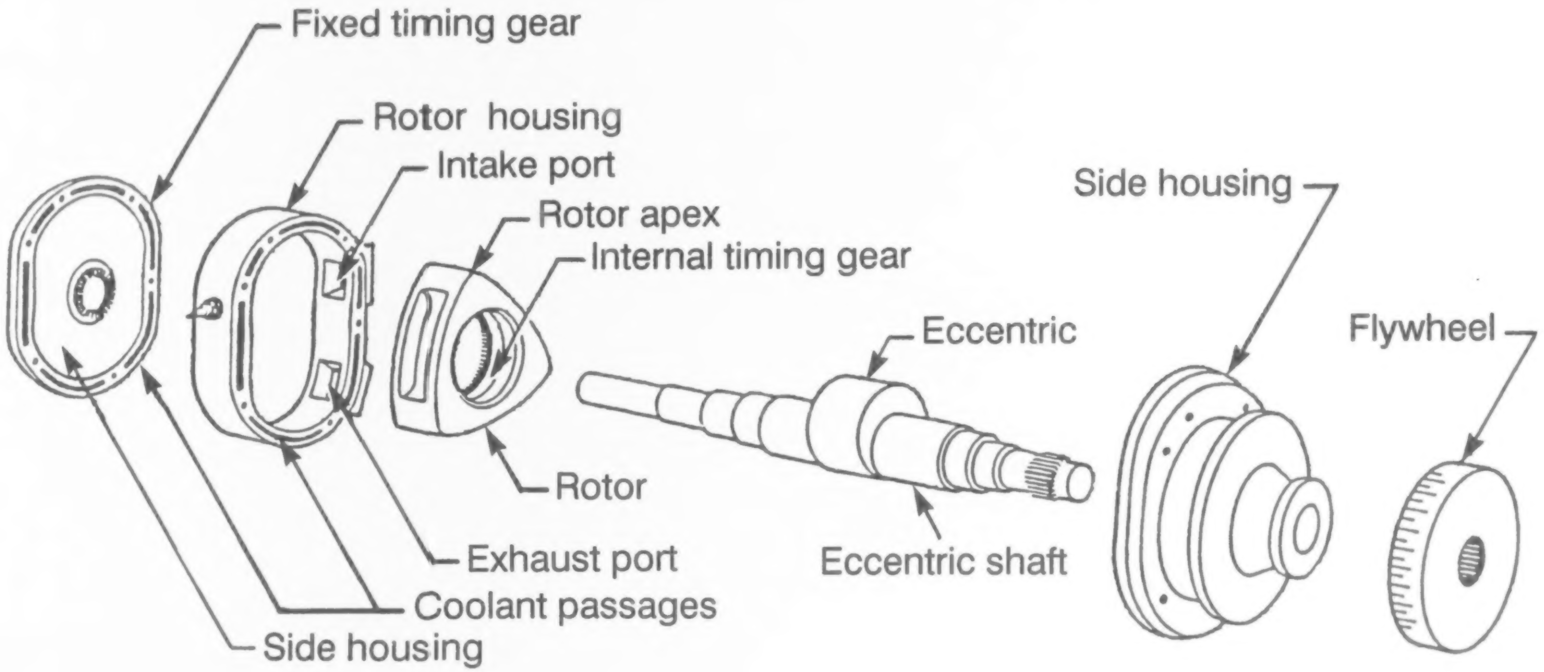
Radial



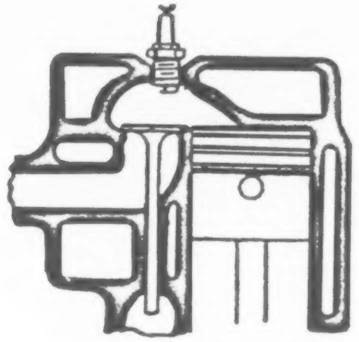


Rotary

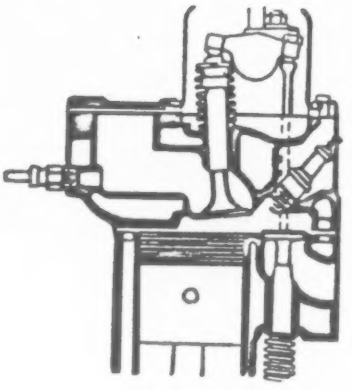
Basic Rotary Engine Parts


Fixed timing gear
Rotor housing
Intake port
Rotor apex
Internal timing gear
Side housing
Eccentric
Flywheel
Rotor
Exhaust port
Eccentric shaft
Coolant passages
Side housing

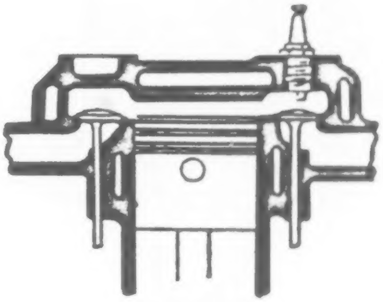
Valve Arrangements



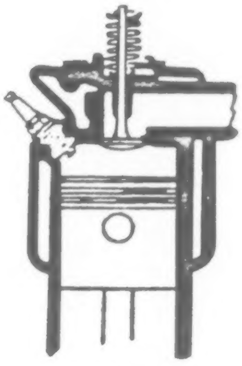
L-Head



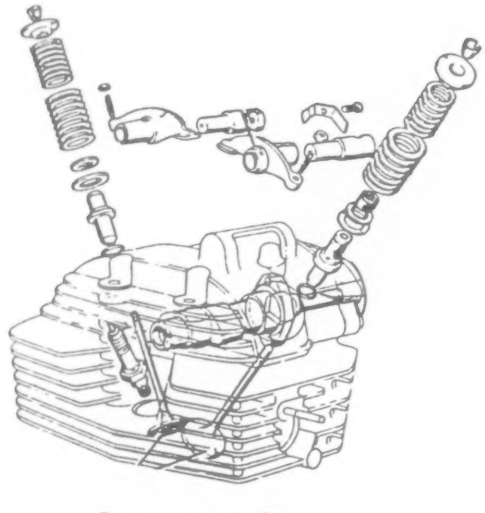
F-Head



T-Head



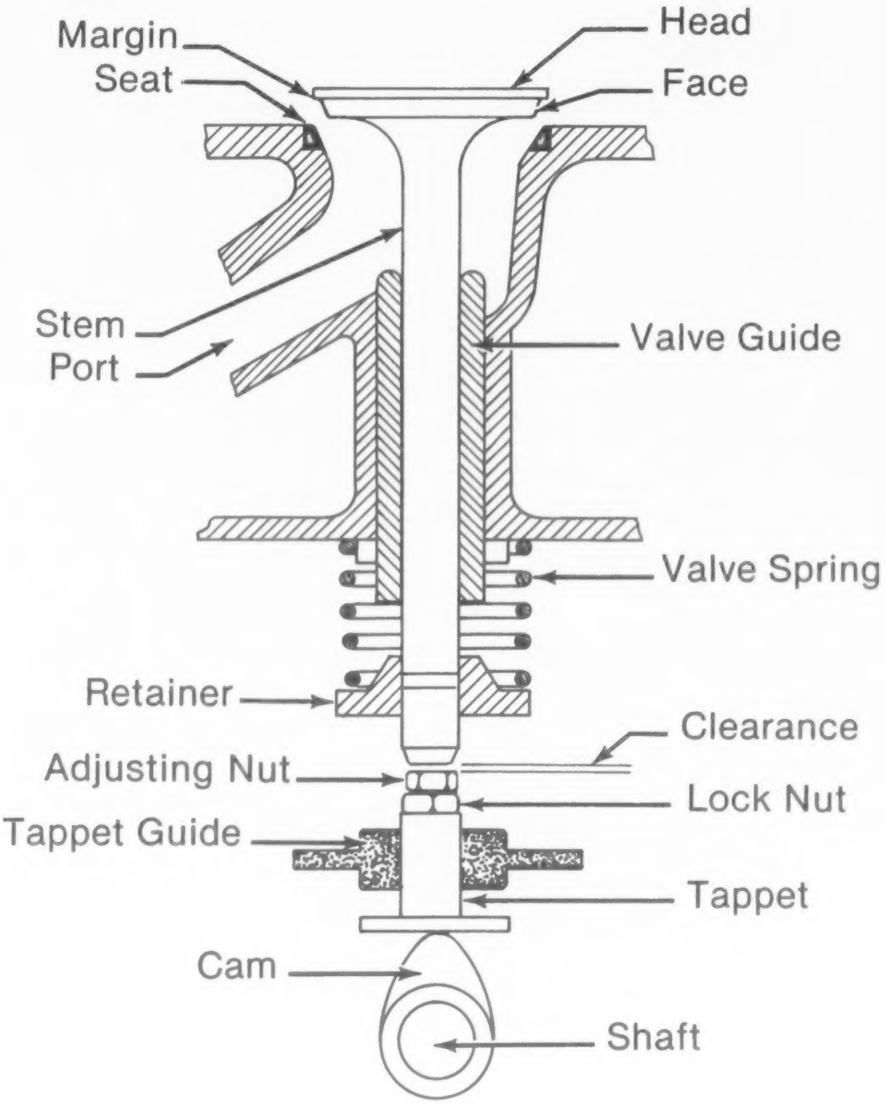
I-Head



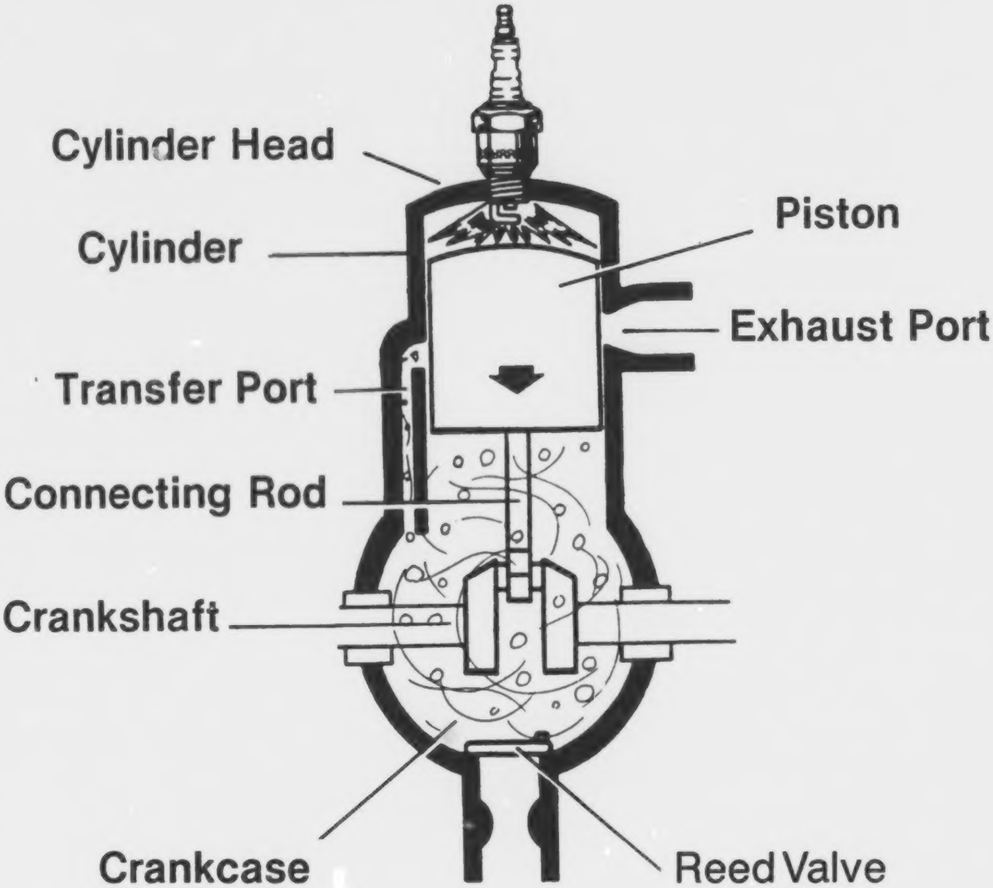
Overhead Cam

BEST COPY AVAILABLE

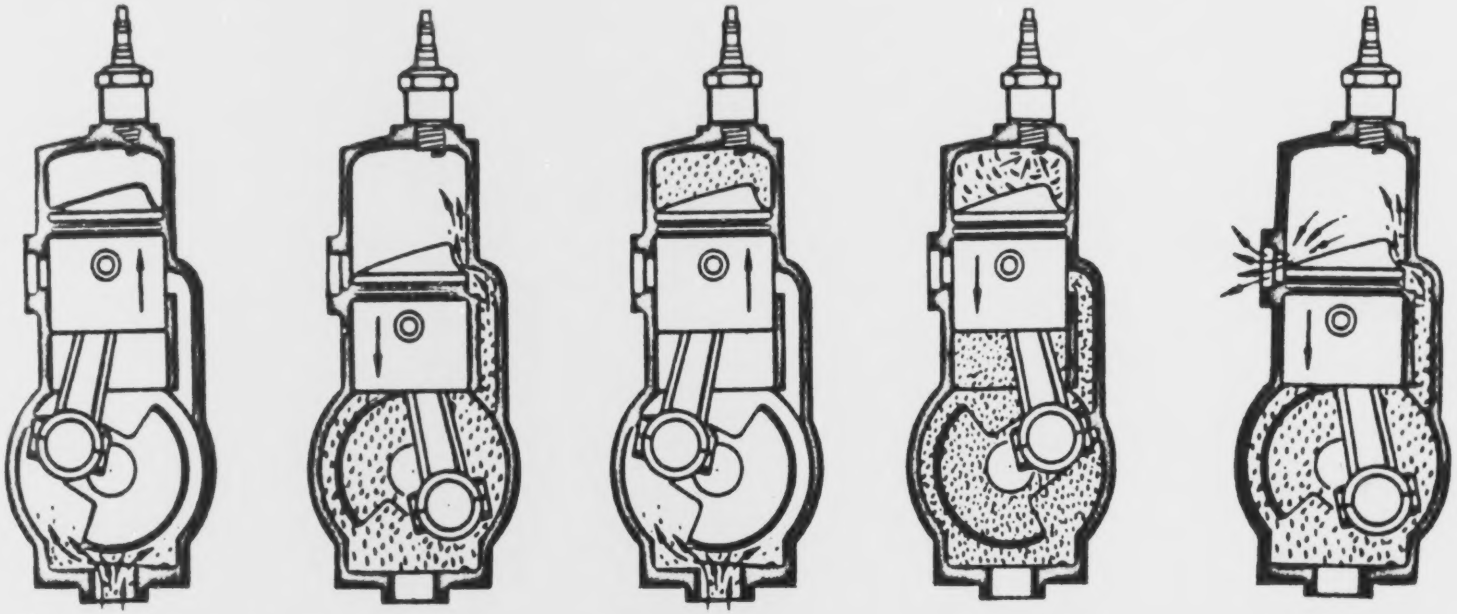
Valve Train


Margin
Seat
Head
Face
Stem
Port
Valve Guide
Valve Spring
Retainer
Clearance
Adjusting Nut
Lock Nut
Tappet Guide
Tappet
Cam
Shaft

Two-Stroke Cycle Engine


Cylinder Head
Cylinder
Piston
Exhaust Port
Transfer Port
Connecting Rod
Crankshaft
Crankcase
Reed Valve

Operation of the Two-Stroke Cycle Engine



Intake Compression Power Exhaust

TM-12

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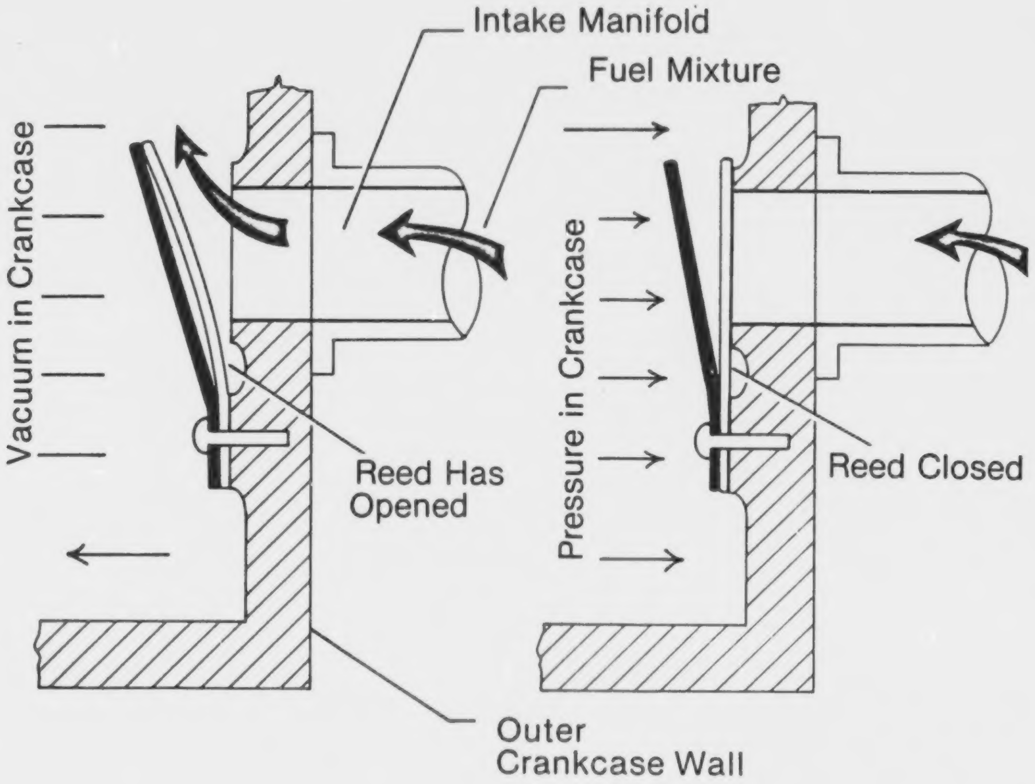
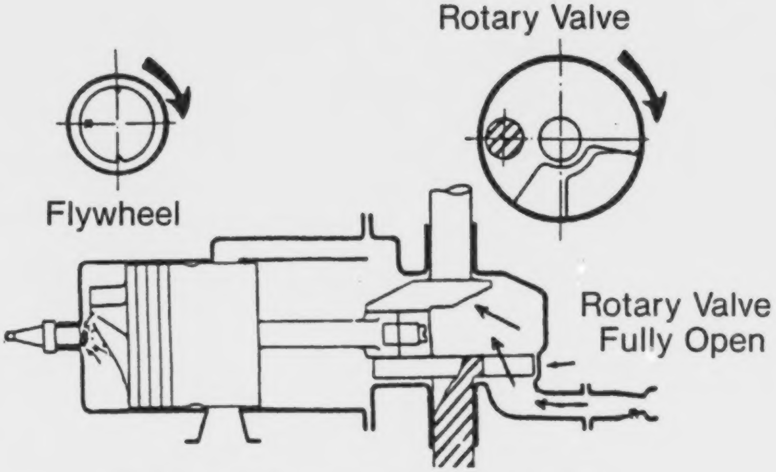
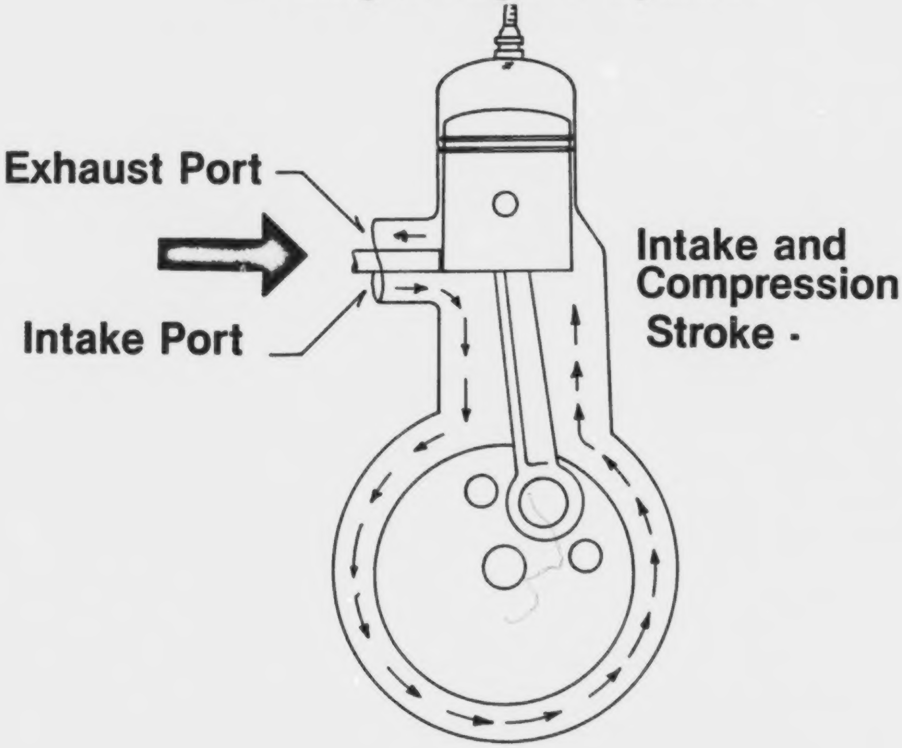
Reed Valves


Intake Manifold
Fuel Mixture
Vacuum in Crankcase
Pressure in Crankcase
Reed Has Opened
Reed Closed
Outer Crankcase Wall

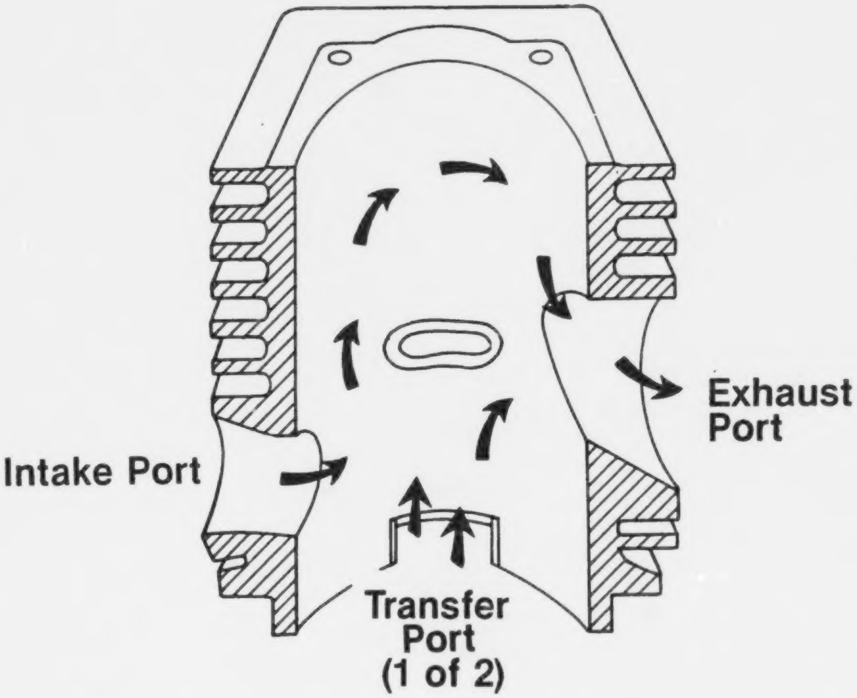
Rotary Valves and Piston Port

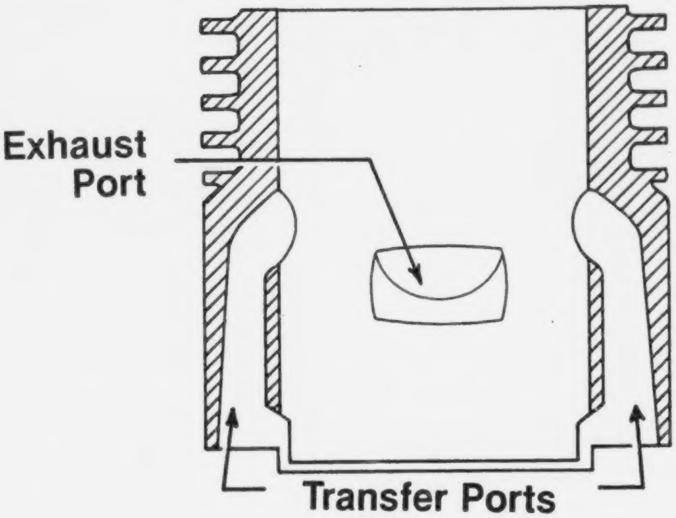

Rotary Valve
Flywheel
Rotary Valve Fully Open

Firing Charge in Cylinder

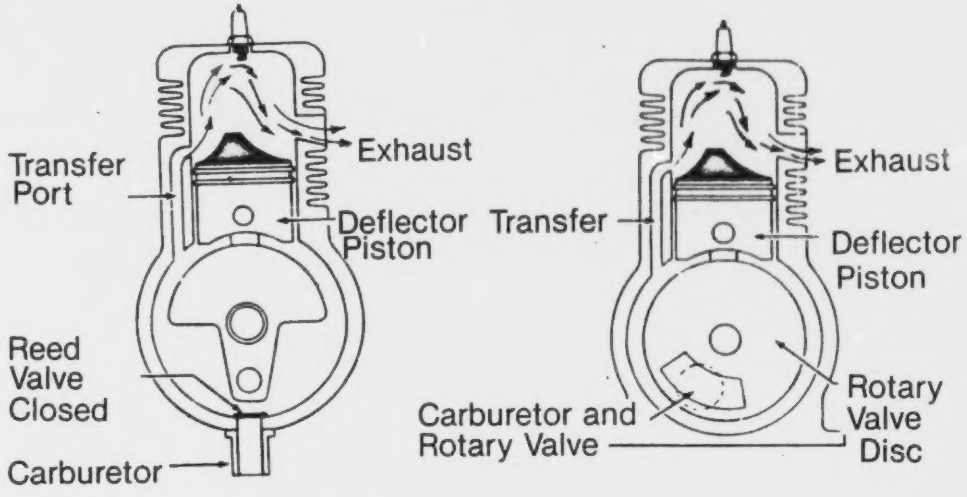

Exhaust Port
Intake Port
Intake and Compression Stroke -

Timing Essentials

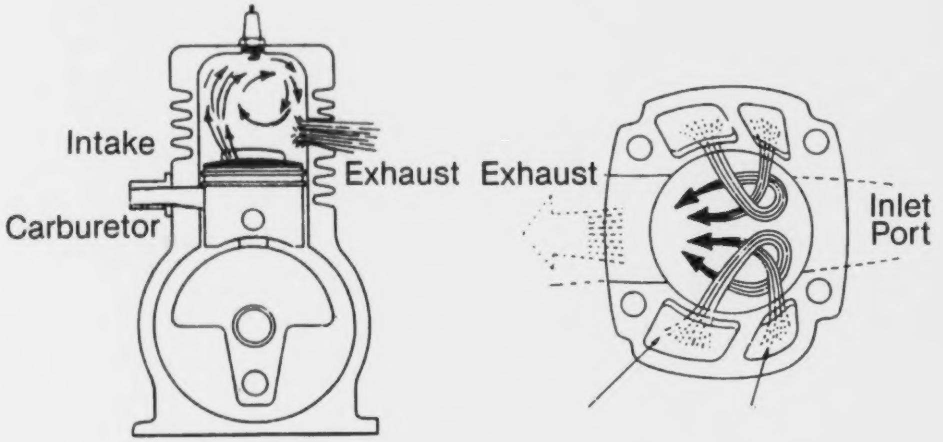

Exhaust Port
Intake Port
Transfer Port (1 of 2)


Exhaust Port
Transfer Ports

Design Variations


Exhaust
Transfer Port
Deflector Piston
Reed Valve Closed
Carburetor
Exhaust
Transfer
Deflector Piston
Rotary Valve Disc
Carburetor and Rotary Valve

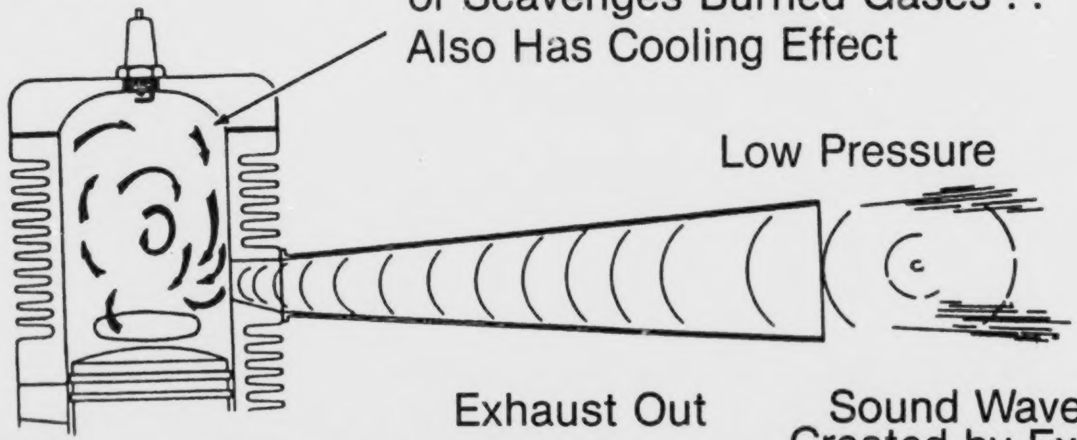
Cross Scavenged


Intake
Exhaust
Carburetor
Exhaust
Inlet Port

Loop Scavenged

Exhaust System Design

Correct



Higher Pressure
Inside Cylinder

Loop Action of Fuel Cleans
or Scavenges Burned Gases . .
Also Has Cooling Effect

Low Pressure

Exhaust Out

Sound Waves
Created by Exhaust

Transfer Port
Pulls New Fuel
Charge in From
Crankcase

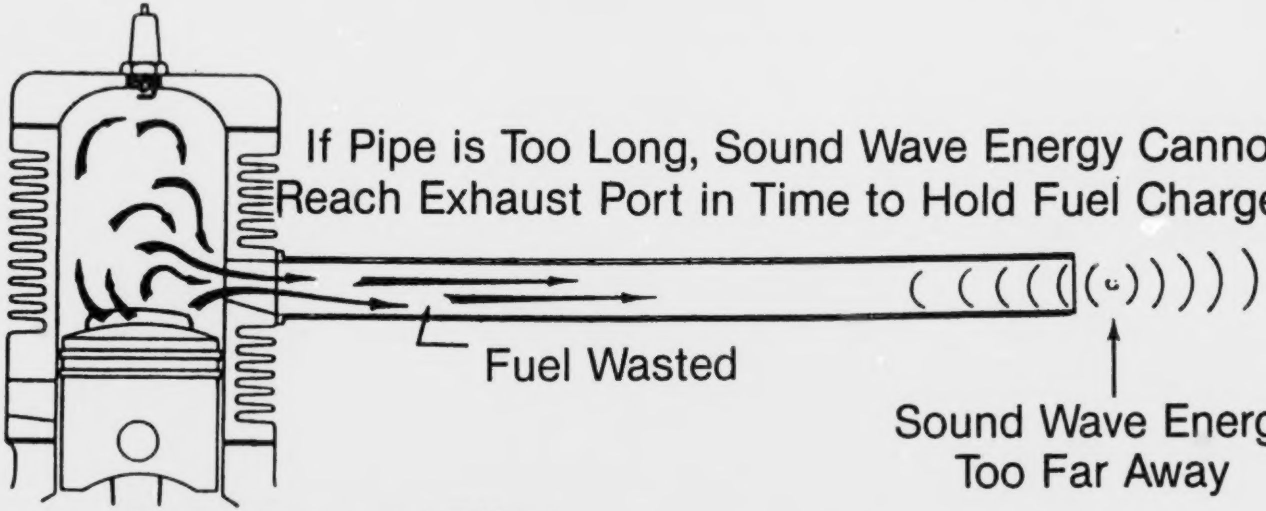
Scavenging Effect

Reflected Sound Waves
Hold Fuel Charge in Cylinder

Without Back Pressure Fuel
Can Go Right Out Open Exhaust

Exhaust System Design

Incorrect



If Pipe is Too Long, Sound Wave Energy Cannot Reach Exhaust Port in Time to Hold Fuel Charge In

Fuel Wasted

Sound Wave Energy Too Far Away

Overscavenged Effect (Pipe Too Long)

Overscavenging From Wrong Length of Exhaust Pipe

ASSIGNMENT SHEET
SMALL ENGINE REPAIR

Name_______________________________ **Date**____________________

UNIT: Engine Principles

TOPIC: Engine Parts and How They Work

DIRECTIONS: Read and answer the following questions in the space provided.

1. Explain the purpose of the combustion engine.

2. Point out the differences between the internal and external combustion engines.

   a. Internal combustion

   b. External combustion

3. Match the terms associated with the parts of the combustion engine with the proper definition by writing each number on the right in the correct blank on the left.

_____a.	The lower part of the piston	1. Piston boss
_____b.	The part of the piston through which the piston pin is inserted	2. Valve face

_____c. The part of the valve that comes into contact with the valve seat

_____d. The housing within which the crankshaft and many other engine parts operate and are oiled

_____e. Area on the engine with which the valve face comes in contact

_____f. Pieces of metal used to secure the valve spring onto the valve

_____g. Connects a rod to the piston

_____h. Device used to start or stop the flow of the air-gas mixture

_____i. A replaceable load-carrying part

_____j. The shaft containing lobes or cams

_____k. The journal for a bearing in the small end of a connecting rod

_____l. A flexible piece of metal used to seal the piston with the cylinder walls during the power and compression strokes

_____m. A round part closed on one end

_____n. Main framework of the piston engine

_____o. A shaft connecting the piston to the crankshaft

_____p. The main shaft running through the engine

_____q. Cuts down on friction

_____r. Provides space to mount external parts

_____s. Installed in a cylinder hole

_____t. Allows fuel to come into the engine

_____u. Used to open the engine valves

_____v. Transfers the force of the explosion from the piston to the crankshaft

3. Piston skirt
4. Crankcase
5. Keepers
6. Piston pin
7. Valve seat
8. Camshaft
9. Valve
10. Bearing
11. Piston
12. Block
13. Connecting rod
14. Ring
15. Crankshaft

_____w. Converts the up and down motion of the piston to usable rotary power

_____x. Houses all internal parts

_____y. Transfers force of explosion to a connecting rod

4. Arrange the events of a power sequence in order, beginning with explosion over piston.

_____a. Explosion over piston

_____b.

_____c.

_____d.

_____e.

_____f.

_____g.

_____h.

1. Push rod drives the rocker arm
2. Piston drives rod
3. Rocker arm opens valve
4. Camshaft drives the lifter
5. Rod drives the crankshaft
6. Lifter raises the push rod
7. Crankshaft drives the camshaft

5. Determine the function of each type of ring used on the piston by placing the correct number to the left of each letter.

_____a. Compression ring

_____b. Wiper ring

_____c. Oil ring

1. Seals the piston within the cylinder and prevents explosion "blow-by"
2. Wipes the oil off the cylinder wall back into the oil pan on the downward movement of the piston
3. Applies oil to the cylinder wall on the upward stroke of the piston

6. Determine the functions of a flywheel by answering "yes" or "no" to each of the following statements.

_____a. The flywheel acts as a balance to smooth the engine.

_____b. The flywheel provides a gear to turn the water pump.

_____c. The flywheel provides a starter gear.

_____d. The flywheel acts as a centrifugal wheel to carry the engine to the next stroke.

_____e. The flywheel changes the direction of rotation to the transmission

7. Identify the three elements necessary to cause an explosion in the cylinder by placing a "√" mark beside the correct answers below.

_____a. water

_____b. fire

_____c. wind

_____d. air

_____e. fuel

8. Arrange the events necessary to start an engine in the proper order by numbering 1 through 4 for each of the following.

_____a. The correct amount of fuel and air mixes

_____b. The spark fires near the top of the compression stroke, which explodes the gas and pushes the piston downward.

_____c. The fuel and air mixture is pulled into the cylinder through the intake valve.

_____d. The engine is cranked which starts it turning.

430

9. Match each of the strokes to the function of the four-stroke cycles of a gasoline engine by placing the correct number to the left of each answer.

_____a. As the piston moves downward, the intake valves open to allow the cylinder to be filled with the correct fuel-air mixture.

_____b. As the piston moves upward, both valves close, causing the fuel and air mixture to be compressed into a small area.

_____c. This action is not considered a stroke, but an event that occurs, causing the fuel-air mixture to explode.

_____d. The piston begins a downward motion, being forced by expanding burning gases.

_____e. The piston moves upward as the exhaust valve opens, allowing the burned gases to be forced from the cylinder.

1. Compression
2. Intake
3. Exhaust
4. Ignition
5. Power

10. Point out the function of each of the parts of the valve train by placing the appropriate number to the left of each letter.

_____a. Camshaft

_____b. Lifter

_____c. Push rod

_____d. Rocker arm

1. Pushes the valve open
2. Pushes the rocker arm
3. Raises the push rods
4. The lobes lift the hydraulic lifters

INFORMATION SHEET
SMALL ENGINE REPAIR

UNIT: Principles of Carburetion

TOPIC: Carburetors

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(C), (ddd)(2)(D)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to discuss the operation of the fuel system and repair each of its components correctly.

SPECIFIC OBJECTIVE(S): After completing this information sheet, the student(s) will be able to explain the purpose and operation of the carburetion and fuel system, and service and repair the components correctly.

BASIC ACADEMIC SKILLS APPLICATIONS: *Basic academic skills used with carburetion include mathematical principles, science, oral and written communications, and the application of reading concepts and skills.*

Carburetors

The carburetor prepares a mixture of air and fuel in the correct proportions for burning in the combustion chamber. The carburetor must function correctly under all engine speeds, varying engine loads, weather conditions and at all engine temperatures. They may have many built-in parts and systems that are complex.

Basic Parts of a Carburetor

The **throttle** controls the speed of the engine by controlling the amount of fuel mixture that enters the combustion chamber. The more fuel mixture, the faster the engine's speed.

The **venturi** is the section of the carburetor that is constricted, or has a smaller cross-sectional area for air to flow through. The venturi is where the gasoline and air are brought together and the mixing begins.

Jets are the small openings in the carburetor through which the gasoline passes. Sometimes they are called **metering holes.**

The **float and float bowl** are found on all carburetors except suction-fed and diaphragm carburetors. The float and float bowl maintain a constant level of gasoline in the carburetor.

The **choke** is used to start the engine and control the air flow into the carburetor. To start the engine, the choke is closed, cutting off most of the engine's air supply. This produces a rich mixture which ignites and burns readily in a cold engine. When the engine starts, the choke should open.

The **needle valve** controls the amount of gasoline available to the carburetor, and regulates the richness or leanness of the fuel mixture.

The **diaphragm** is a piece of flexible material stretched across the pressure chamber of a carburetor or fuel pump that controls the amount of fuel entering the chamber.

The **fuel pump**, used on many small engines such as two-stroke cycle outboard motors, is simple and consists of a chamber, inlet and discharge valves, a rubber diaphragm, and a spring. This type of fuel pump is operated by crankcase pressure. As the pressure in the crankcase pulls the diaphragm toward the crankcase, fuel is pulled through the inlet valve into the fuel chamber. Then the piston comes down, pushing the diaphragm away from the crankcase, and closes the intake valve. The discharge valve is opened, allowing the fuel to be forced into the carburetor.

The **Air cleaner** is needed because each intake stroke of the engine not only pulls in air, but also dust and dirt, which must be kept out of the engine cylinder. The dirt will scratch the cylinder walls and rings, and a dirty engine wears out very quickly. Therefore, an air filter is needed to clean the air before it enters the engine. See TMs 10-13.

The **Fuel filter** is a screen which is placed in the tank fitting or at the end of the pick up line. Other engines have a bottom mounted fuel fitting with a shut-off valve threaded into the tank. Having this valve, one avoids the need to drain the fuel tank when working on the engine or in case of a fuel line failure. Some small engines have a filter incorporated into a glass sediment bowl. The gasket, screen, and bowl can be removed for inspection and cleaning. This type of filter can be mounted directly on the fuel tank and has a shut-off valve. See TM 6.

Float Type Carburetors

The **float carburetor** uses a float to control the fuel level as shown on TMs 14 and 17. Most float type carburetors have both low and high speed adjustment screws, and also have both a throttle valve and a choke valve.

The **nozzle tube** contains holes and delivers the fuel from the float bowl to the venturi. The nozzle tube operates in the same manner as a fuel pipe in a suction carburetor.

When the engine is running at slow speed, the throttle valve is closed. The small hole in the throttle valve creates a vacuum, and causes more fuel to be pulled through the nozzle. The small amount of gas will go out of the hole into the engine, and is sufficient fuel to run the engine.

When starting a cold engine, the choke valve will be closed, allowing less air to enter the carburetor. The engine piston creates a strong vacuum and pulls fuel through the nozzle into the engine so that it starts.

When the engine is running fast, the throttle valve is open. As air enters the carburetor, it passes through the venturi and low pressure develops. This causes fuel to be pulled from the fuel bowl through the nozzle. Air and fuel mix together in the venturi and enter into the engine cylinder. The amount of fuel entering the nozzle is controlled by the high-speed screw. The air holes in the nozzle aid in breaking up the fuel on its way out of the nozzle.

Diaphragm Carburetor

The diaphragm carburetor is designed to work in any position. The top part of the carburetor is the same as the suction or float carburetors. It has a choke valve, throttle valve, venturi, and high and low speed adjustment screws. Instead of having a float bowl, however, it contains a diaphragm. The diaphragm controls a small amount of fuel in a fuel chamber. A fuel inlet allows the fuel to enter the carburetor.

The diaphragm is made from a flexible, rubber-like material that is stretched across a small space called a chamber. At the center of the diaphragm, a control lever is connected to a needle valve. The needle valve operates the same way it does on a float carburetor. A small spring fits between the top of the chamber and the control lever that is connected to a small pivot.

As the fuel flows to the inlet, the spring pushes down on the control lever and lets the needle valve drop, allowing fuel to enter around the needle valve. As fuel fills the chamber, it pushes down on the diaphragm and causes the control lever to pivot upward, pushing the needle valve up to close the fuel inlet. When the fuel is used, the diaphragm will rise and the needle will open again and let fuel enter.

Suction Carburetor

The most commonly used carburetor is the suction or vacuum type carburetor. This type of carburetor is mounted on top of the fuel tank, and fuel is pulled from the tank by a vacuum. These carburetors are also known as vacu-feed or vacu-jet carburetors.

As the piston moves down the cylinder, a vacuum is created inside the carburetor which pulls the fuel up the fuel pipe. The high speed adjustment screw controls the amount of fuel entering the venturi. The throttle valve slows down the amount of air much like a venturi does and helps suction fuel up the pipe. There are two holes called **metering** or **discharge holes** through which fuel enters the carburetor. When the throttle is open, fuel comes out both holes. If the throttle is closed, fuel comes out only one of the holes. This will allow the engine to run with the throttle in closed position. The choke is a sliding plate at the outer end of the carburetor, and it is pulled out to close off air. This helps start a cold engine. When the engine starts, the choke is pushed in.

High-Speed Fuel Adjustment

An engine running at high speed needs air and fuel. When the air enters the carburetor then goes through the venturi, the vacuum in the venturi pulls fuel through the pick up tube. The fuel mixes with air and enters the cylinder. The amount of fuel entering is controlled by a screw with a pointed end that fits into the pickup tube that opens or closes the pickup tube. If the screw is turned in, the fuel will be slowed down; if it is turned out, the fuel will go up the tube. This adjustment is used to control the amount of fuel going into the engine at high speed.

Low-Speed Fuel Adjustment

To run the engine slowly, close the throttle valve so little air goes through the venturi, and little fuel is pulled through the pick up tube. This is accomplished by means of a small hole behind the throttle valve. A small screw with a pointed end is used to control the amount of fuel which comes out of the hole. The pointed end of this screw goes through the side of the carburetor and into the fuel passage. If the screw is all the way in, very little fuel can come out the hole. As the screw is turned out, more fuel comes out the hole. This is used to control the low speed adjustment.

Governors

The governors and the carburetor throttle valve control the speed of an engine. When the throttle is open, the engine runs fast; when the throttle is closed, the engine runs slow. Another speed control on some engines is the governor. The governor helps keep the engine at a steady speed by opening or closing the throttle. If the engine is not working hard, it closes the throttle. If it is working hard, the governor will open the throttle for more power. One type of governor is the **air vane,** and the other is the **mechanical governor.**

The **air vane** operates using the force of air from the flywheel. The flat piece of steel or plastic mounted above the flywheel is the air vane. It is connected to the throttle valve with a wire called a **link**. A spring is connected to the link to open the throttle. When the engine is running, air is thrown off the fly wheel and hits the air vane. The faster the engine runs, the stronger the force of air is on the air vane. This causes more force to close the throttle valve.

The governor spring works against the air vane and tries to pull the throttle open. When using a hand throttle on a lawn mower, if you pull on the cable that is connected to the spring, it places more tension on the spring and the engine runs faster. As the tension is released, the engine runs slower. The **spring** and the **air vane**, working together, keep the engine speed steady.

Some engines use a **mechanical governor** connected inside the engine. A small set of counterweights is attached to a small gear that rides on the camshaft gear. A governor spring attached to the hand control holds the throttle open. As the engine runs, the camshaft gear makes the governor gear turn at a high speed, causing the counterweights to fly outward. As a result, a pin attached to the weights moves. This pushes against an arm and lever. With this movement, the lever pulls on the link connected to the throttle. As the throttle is closed, the engine slows down. Together the spring and the counterweights cause the engine to run at a steady speed.

Terms and Definitions

Air cleaner removes the dirt and dust from air before it enters the carburetor.

Carburetor mixes the correct amount of air and fuel for engine operation.

Diaphragm carburetor controls the amount of fuel entering the engine through use of a diaphragm.

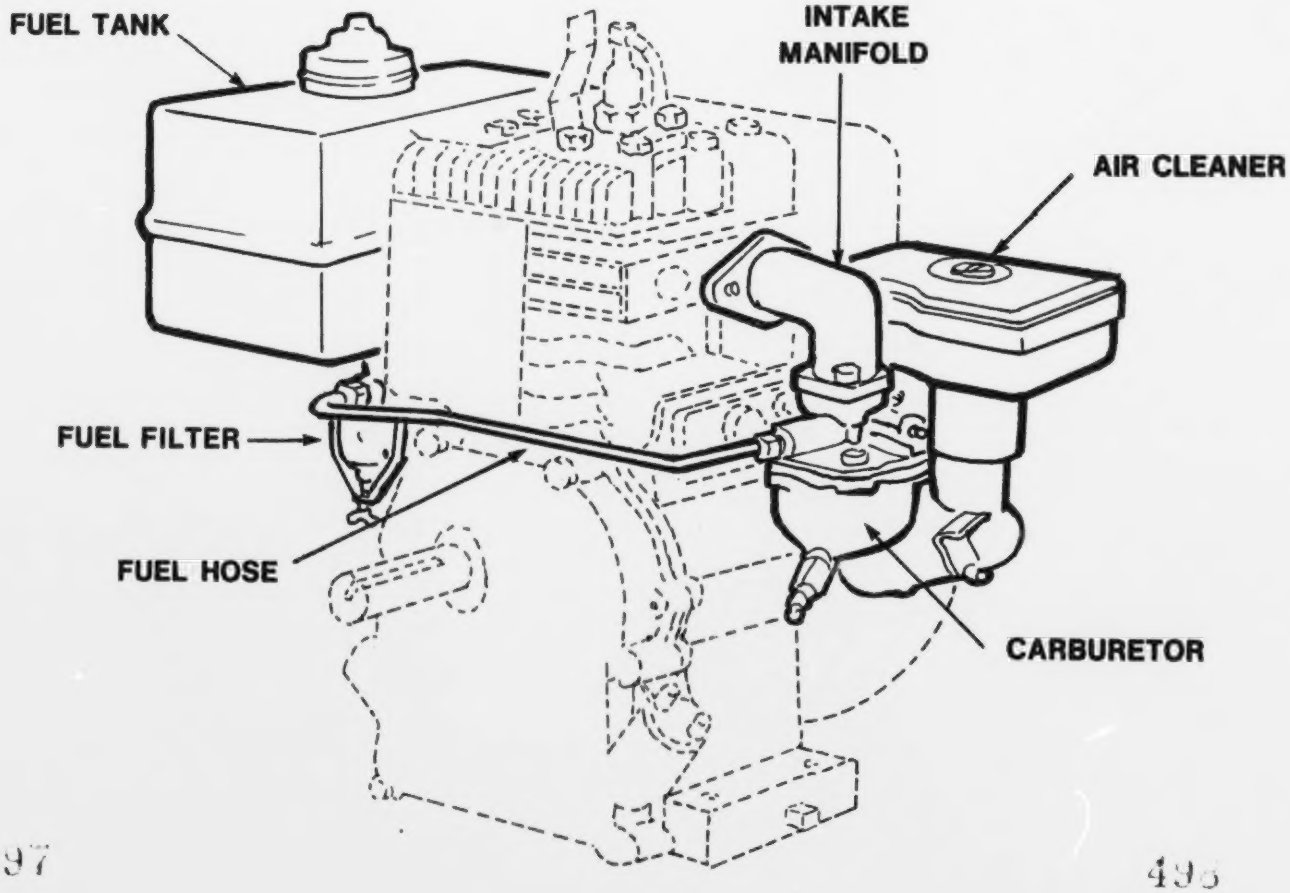
Float controls the amount of fuel in the float bowl.

Float carburetor controls the amount of fuel entering the engine with a float.

High-speed adjustment controls and adjusts fuel mixture when engine is operating at high speed.

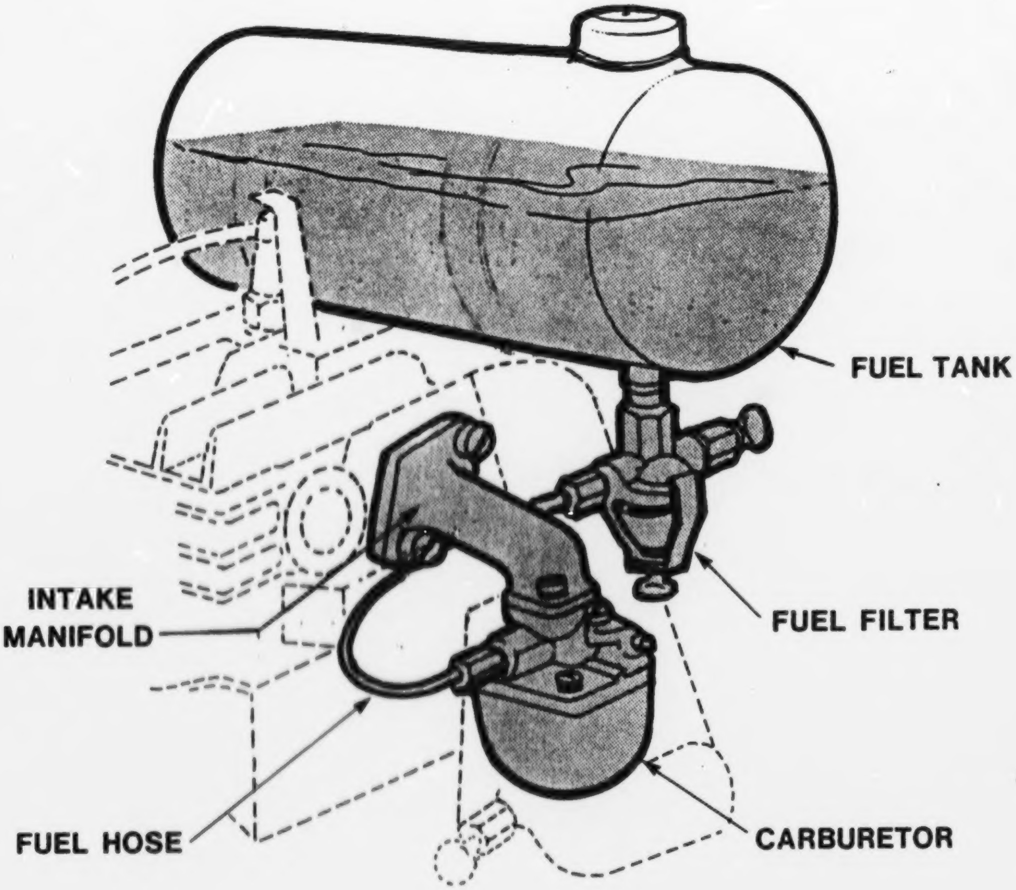
Low-speed adjustment controls and adjusts fuel mixture when engine is operating at low speed.

MAJOR PARTS OF THE FUEL SYSTEM

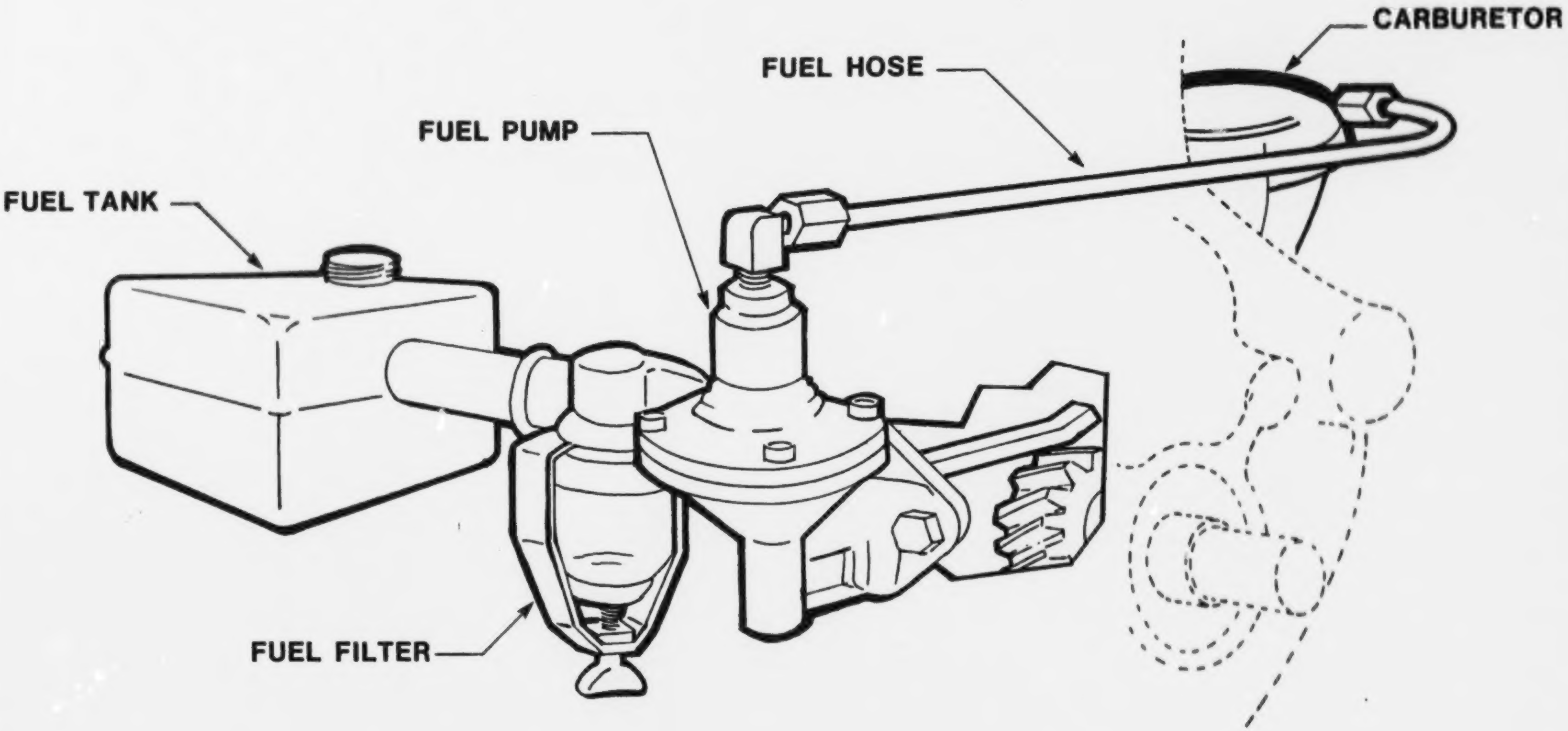

FUEL TANK
INTAKE MANIFOLD
AIR CLEANER
FUEL FILTER
FUEL HOSE
CARBURETOR

TM-1

GRAVITY-FEED FUEL SYSTEM


FUEL TANK
INTAKE MANIFOLD
FUEL FILTER
FUEL HOSE
CARBURETOR

PUMP-FEED FUEL SYSTEM

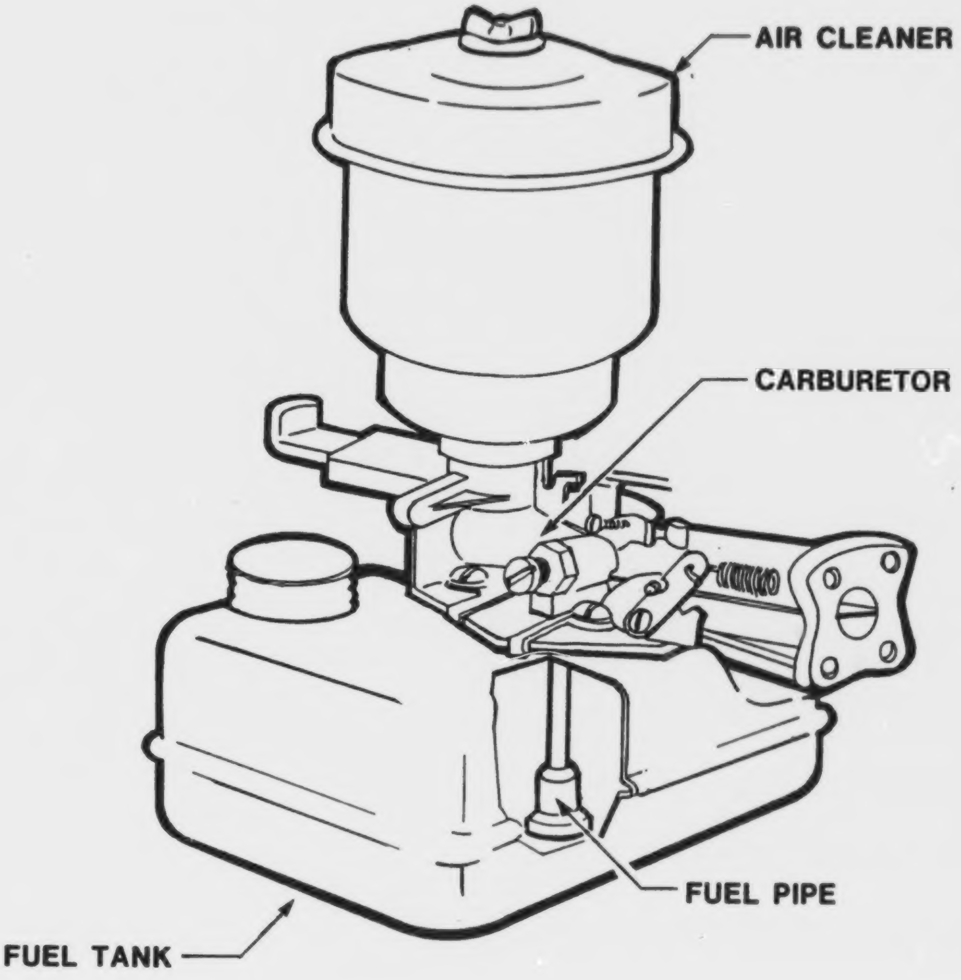

CARBURETOR
FUEL HOSE
FUEL PUMP
FUEL TANK
FUEL FILTER

TM-3

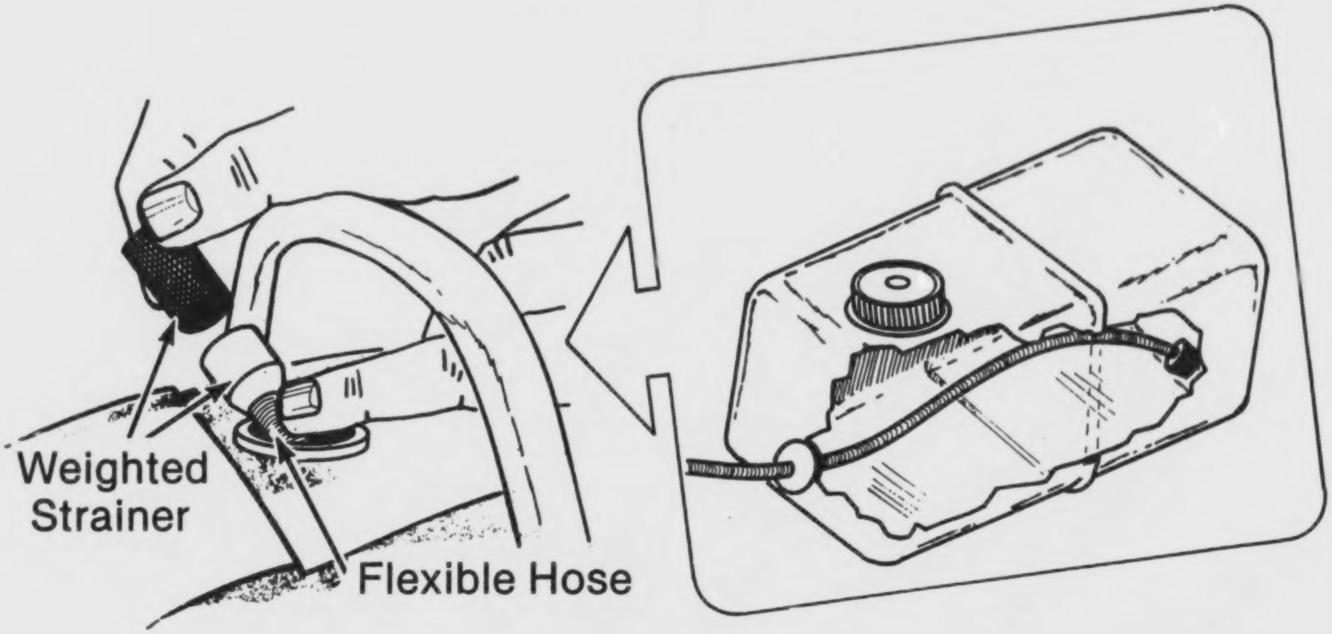
500

501

SUCTION-FEED FUEL SYSTEM


AIR CLEANER
CARBURETOR
FUEL PIPE
FUEL TANK

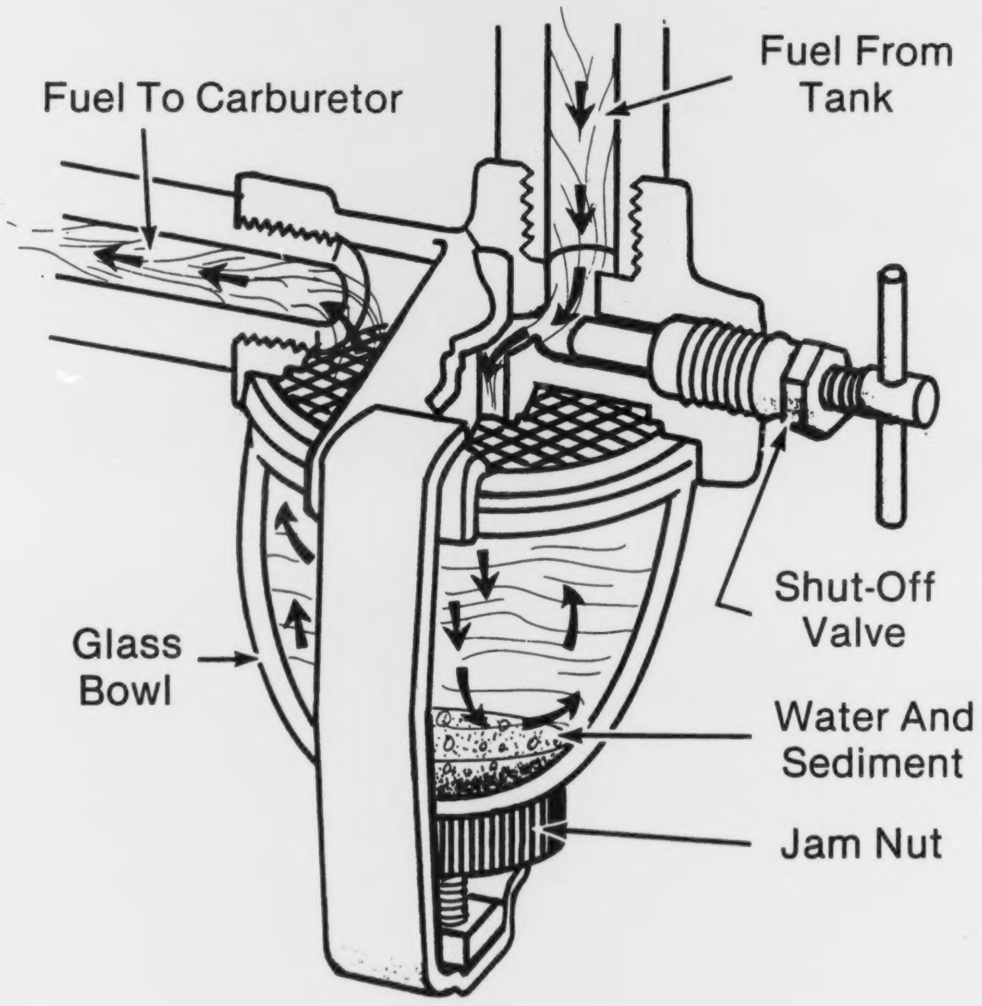
Fuel Filter


Weighted
Strainer
Flexible Hose

Filter attached to end of flexible fuel hose.

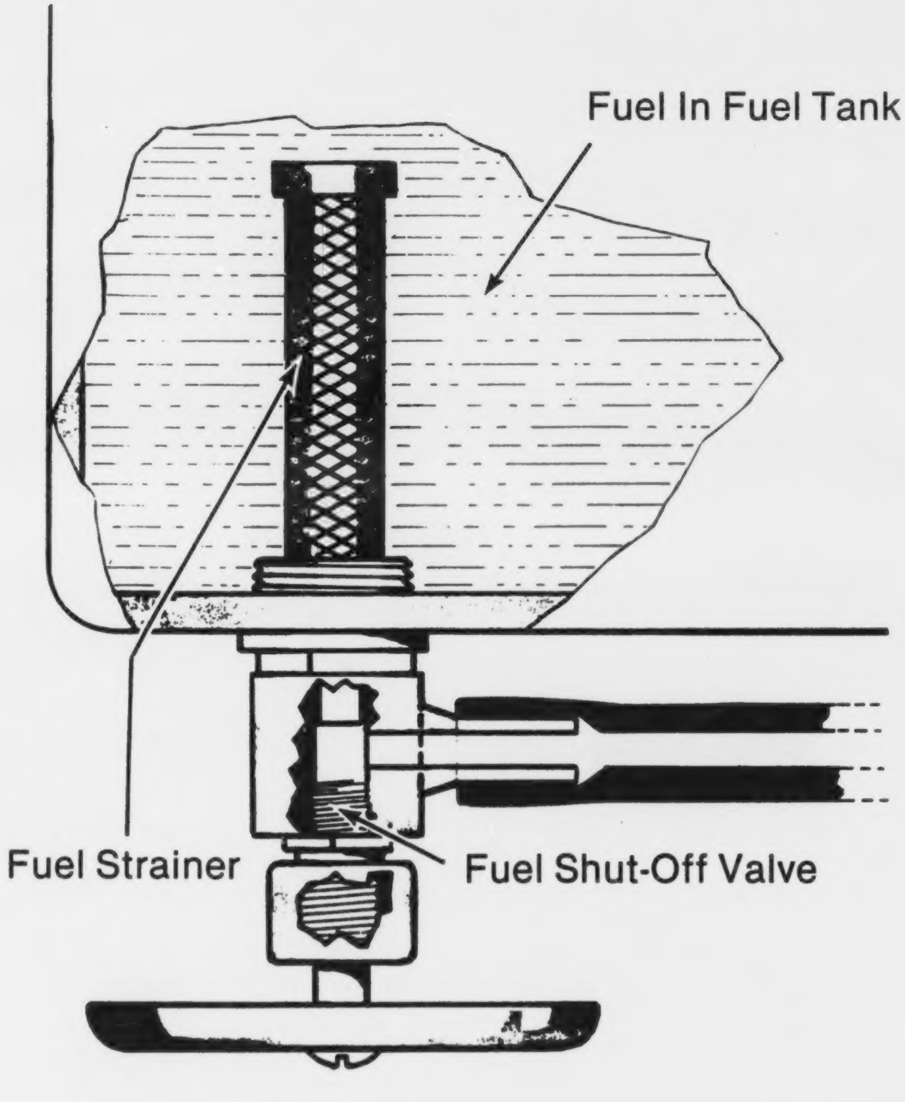
Fuel Filter

(Glass Sediment Bowl And Screen)

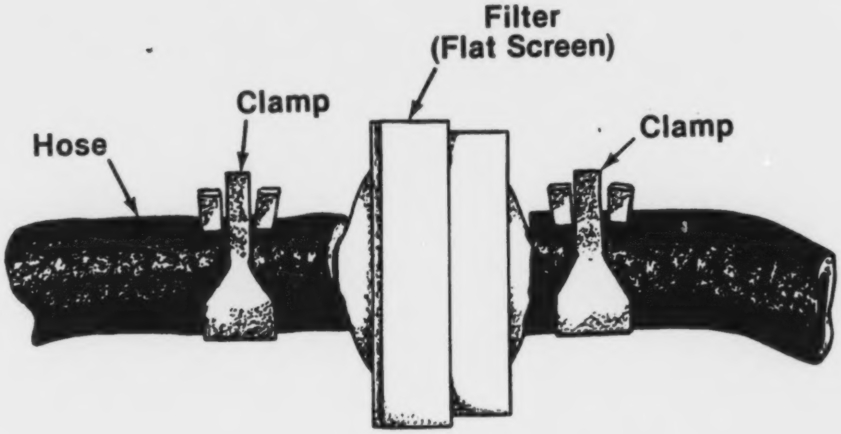

Fuel To Carburetor
Fuel From Tank
Shut-Off Valve
Glass Bowl
Water And Sediment
Jam Nut

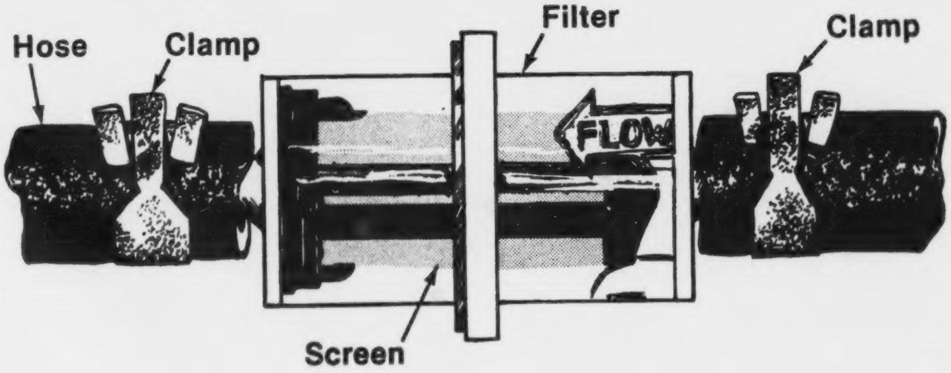
Fuel Filter

(Screen In Tank)

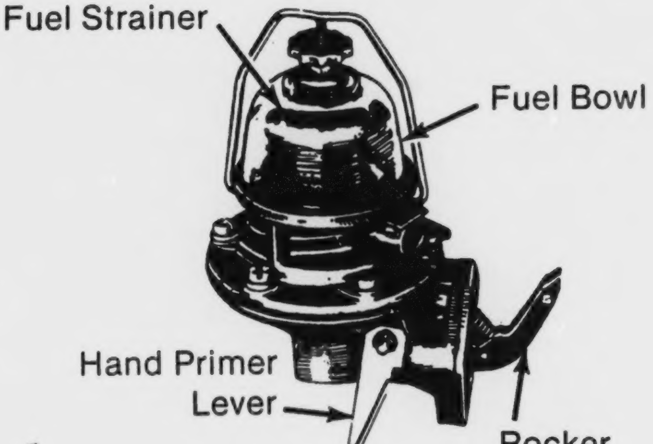

Fuel In Fuel Tank
Fuel Strainer
Fuel Shut-Off Valve

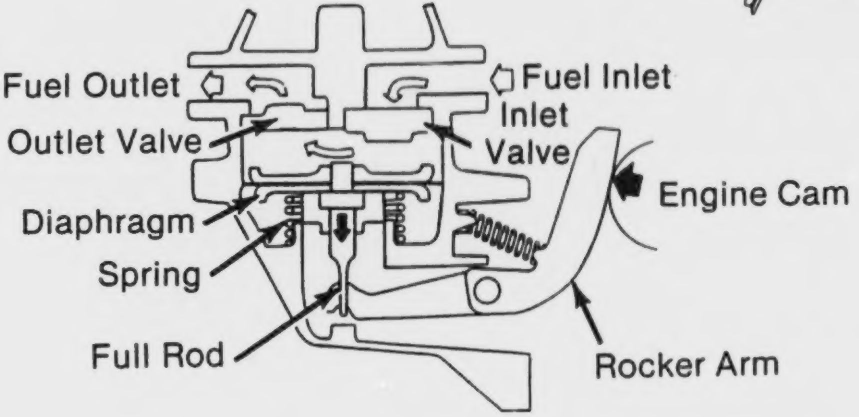
Fuel Filter
(In-Line)

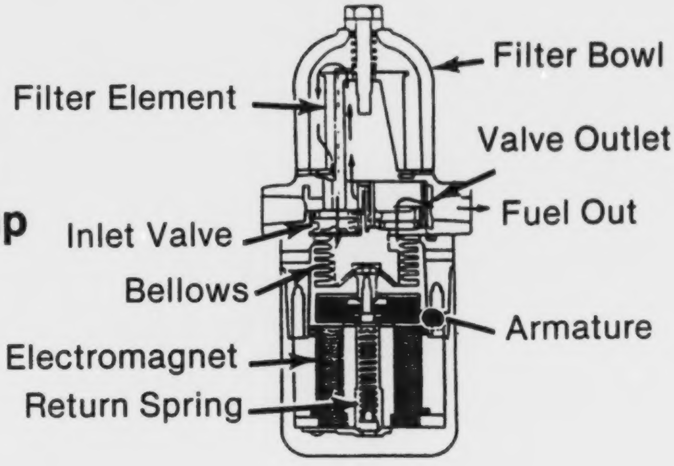

Filter
(Flat Screen)
Clamp
Hose
Clamp


Hose
Clamp
Filter
Clamp
FLOW
Screen

Operation of Fuel Pump


Fuel Strainer
Fuel Bowl
Hand Primer Lever
Rocker Arm

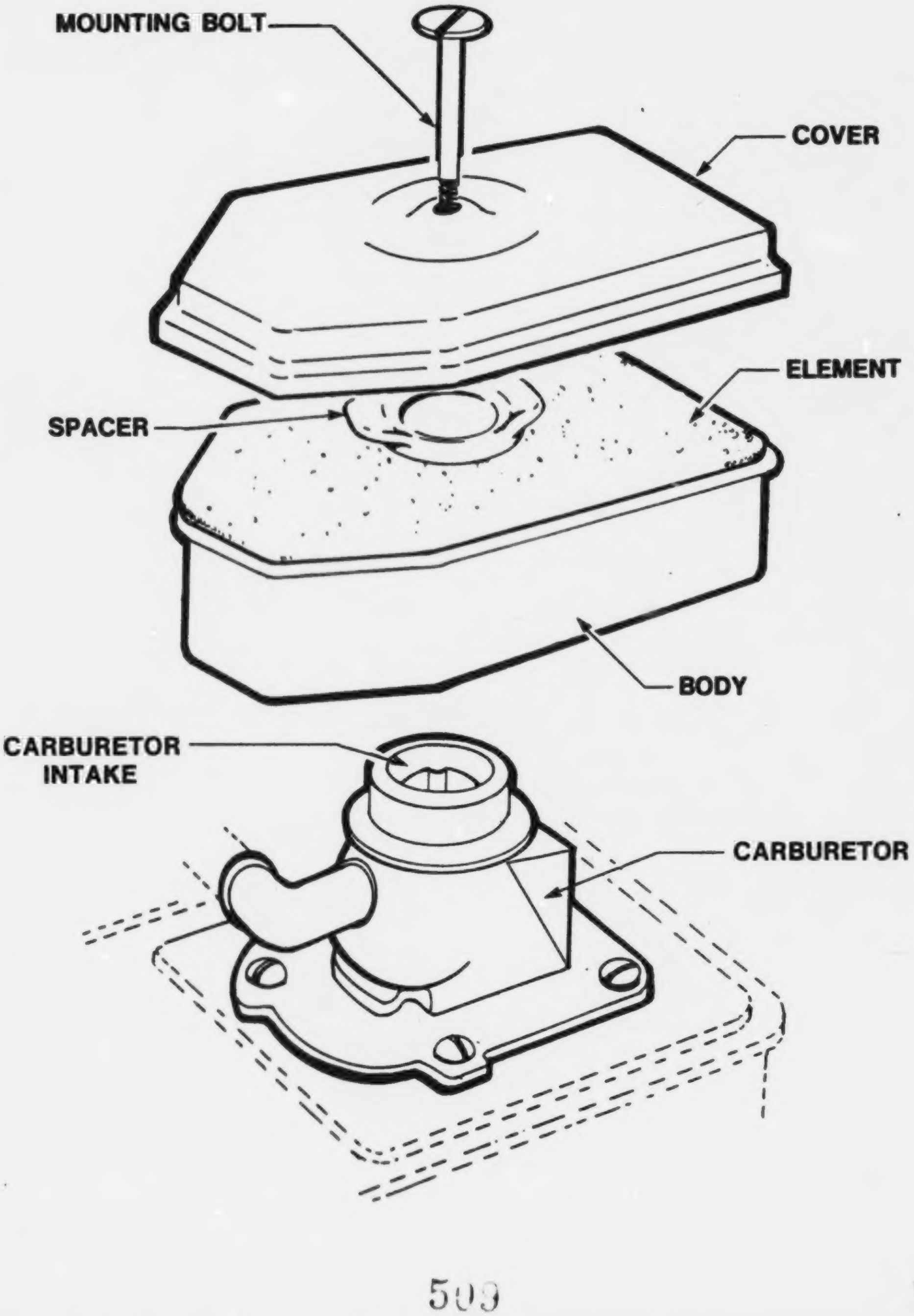

Fuel Outlet
Fuel Inlet
Outlet Valve
Inlet Valve
Engine Cam
Diaphragm
Spring
Full Rod
Rocker Arm


Filter Bowl
Filter Element
Valve Outlet
Fuel Out
Inlet Valve
Bellows
Armature
Electromagnet
Return Spring

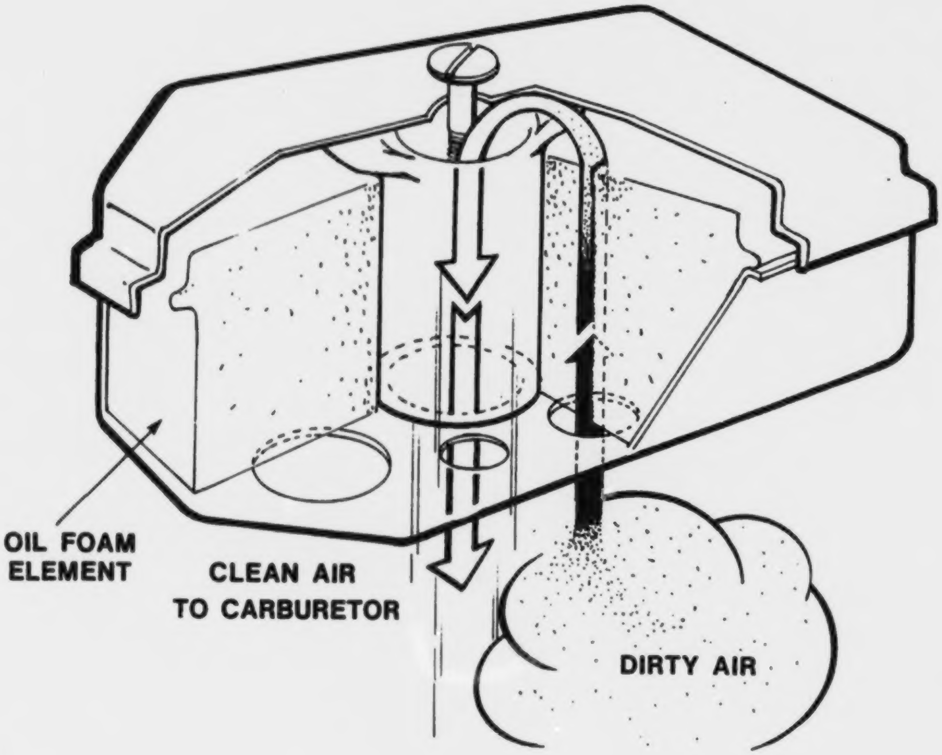
Cutaway View of Electric Fuel Pump

BEST COPY AVAILABLE

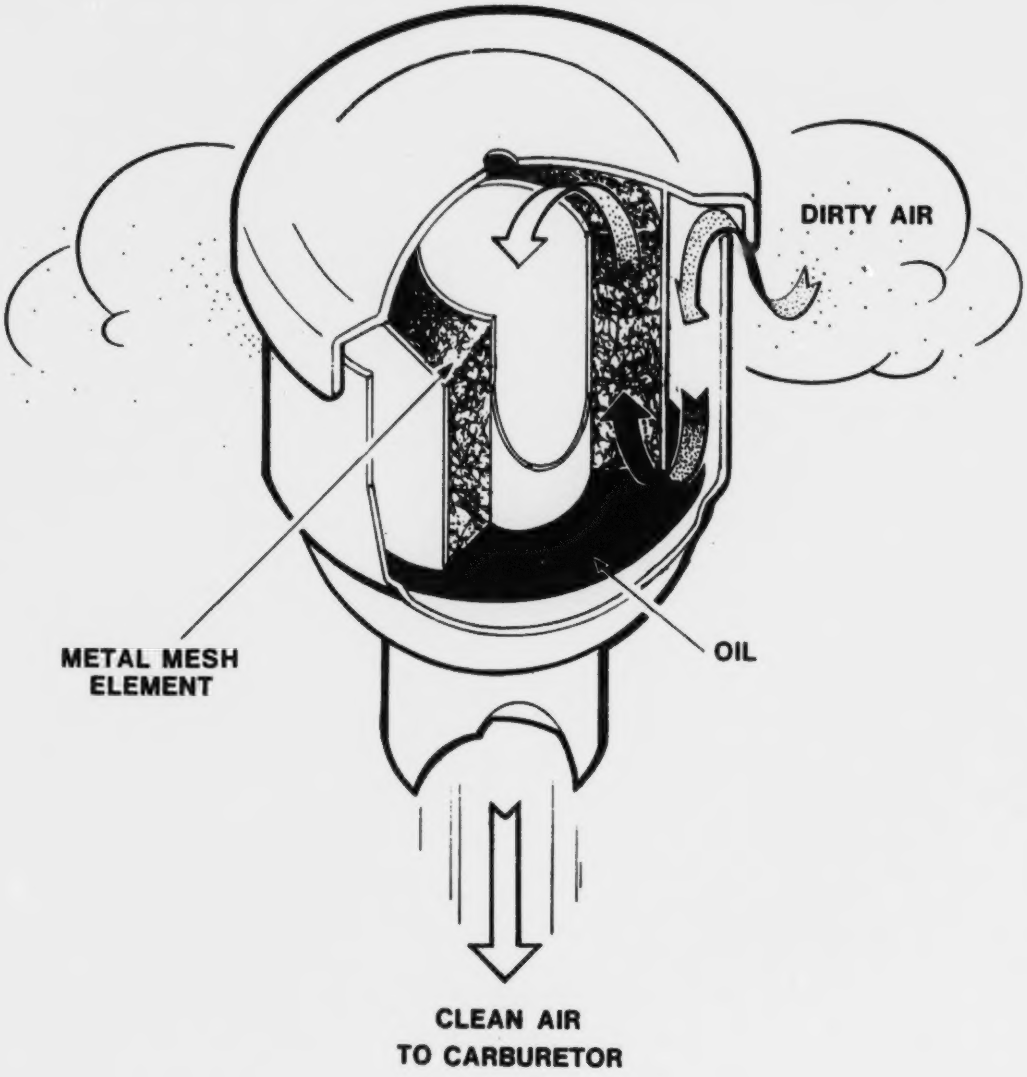
PARTS OF AN AIR CLEANER


MOUNTING BOLT
COVER
ELEMENT
SPACER
BODY
CARBURETOR INTAKE
CARBURETOR

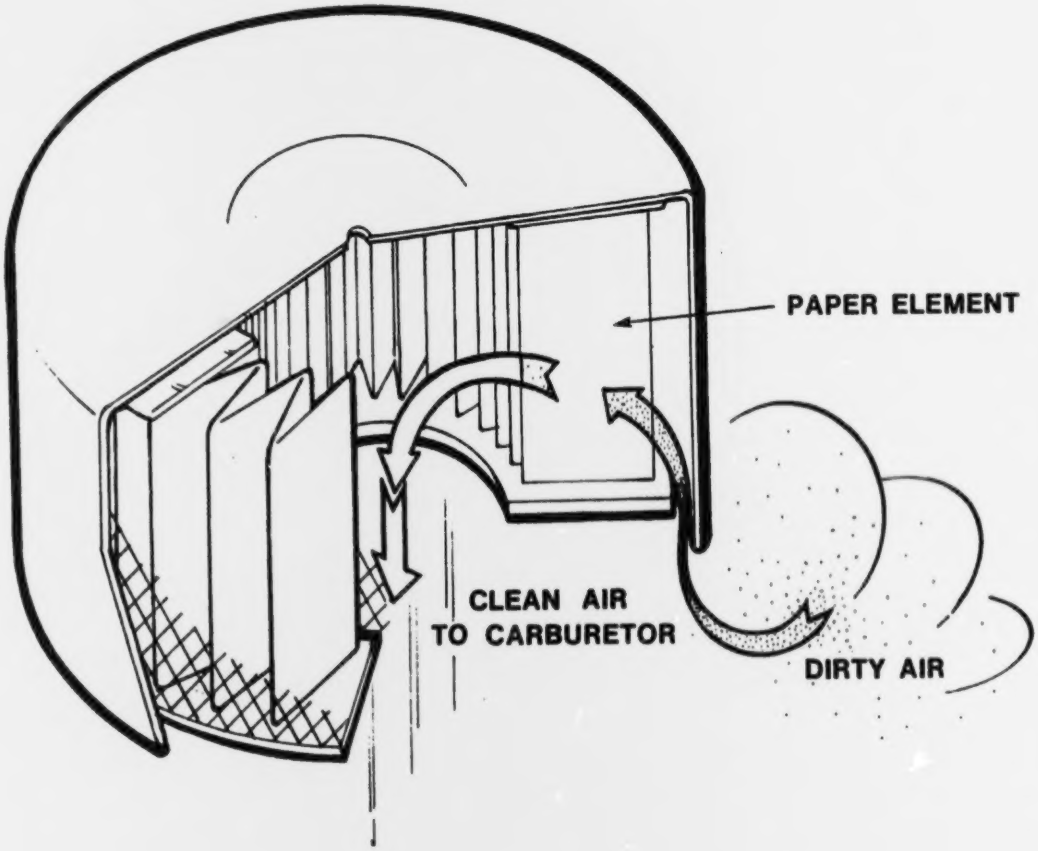
OIL-FOAM AIR CLEANER


OIL FOAM ELEMENT
CLEAN AIR TO CARBURETOR
DIRTY AIR

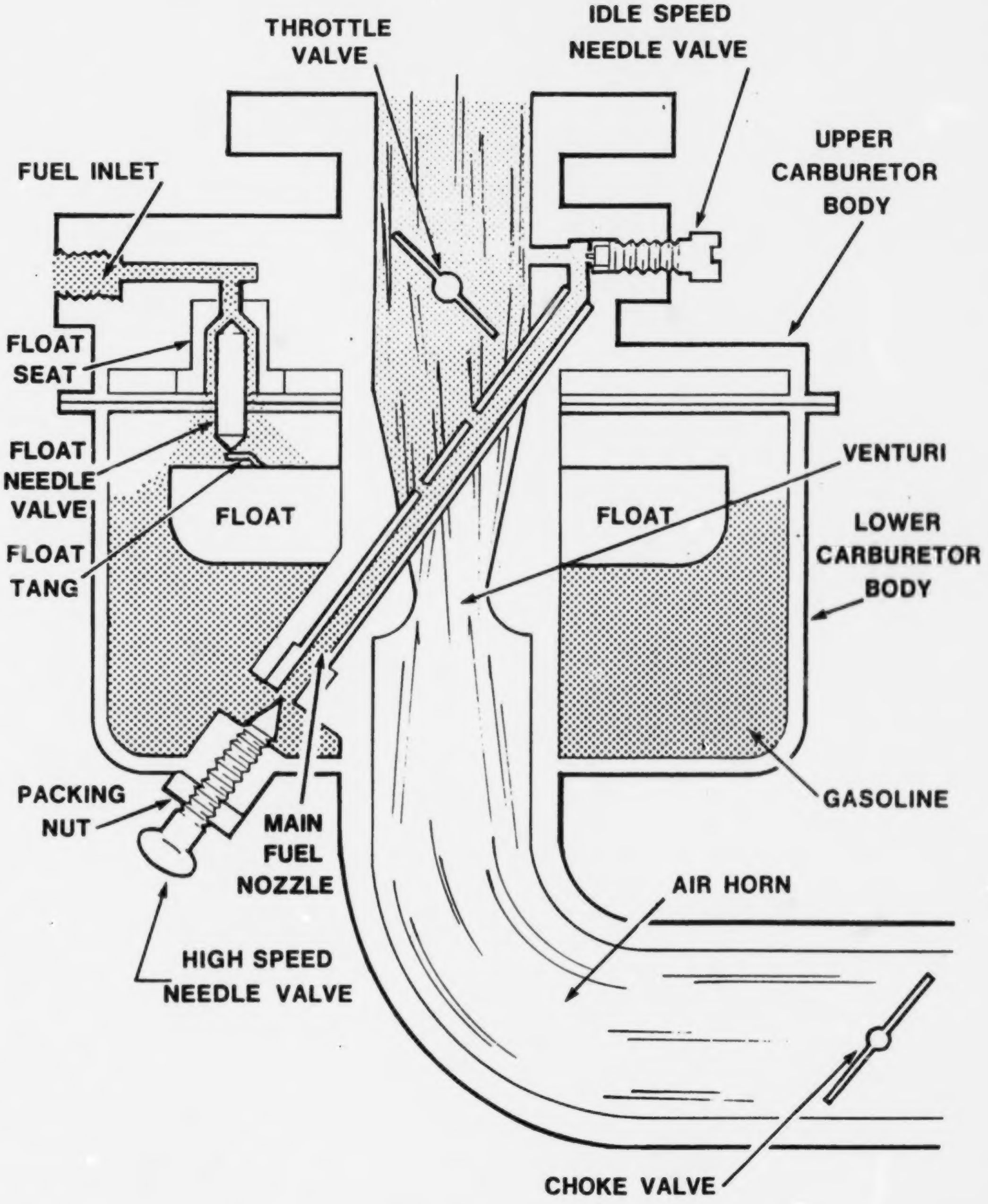
OIL-BATH AIR CLEANER


DIRTY AIR
METAL MESH ELEMENT
OIL
CLEAN AIR TO CARBURETOR

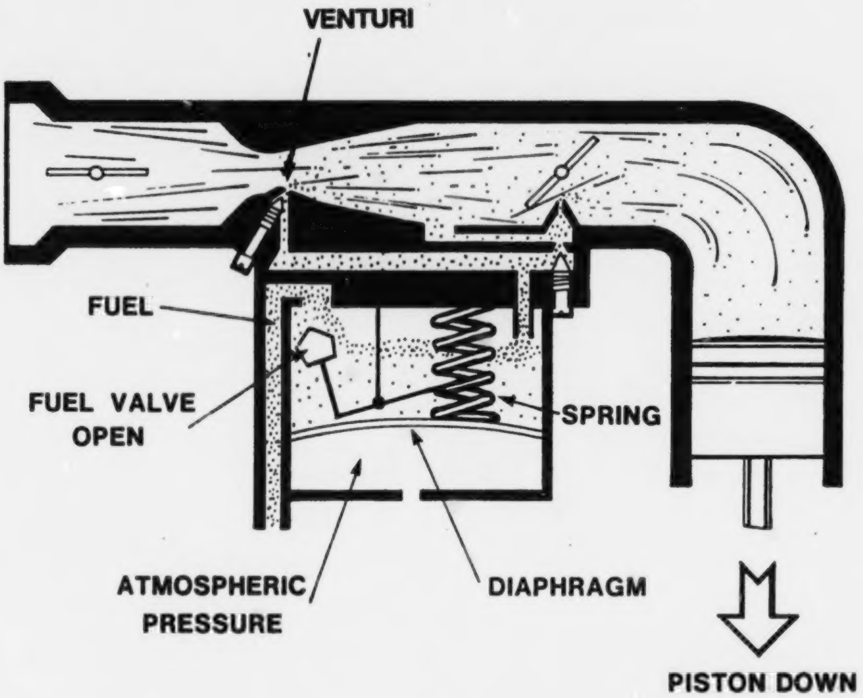
DRY AIR CLEANER

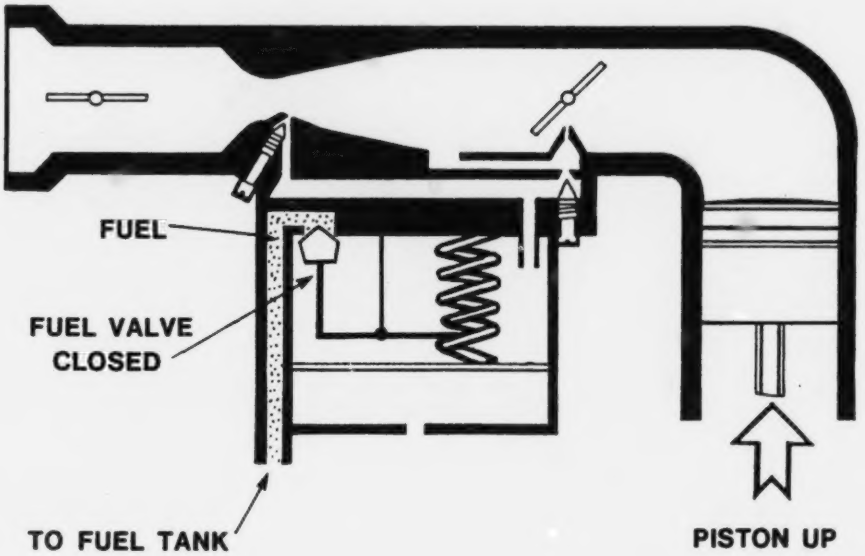

PAPER ELEMENT
CLEAN AIR TO CARBURETOR
DIRTY AIR

PARTS OF A TWO-PIECE FLOAT CARBURETOR

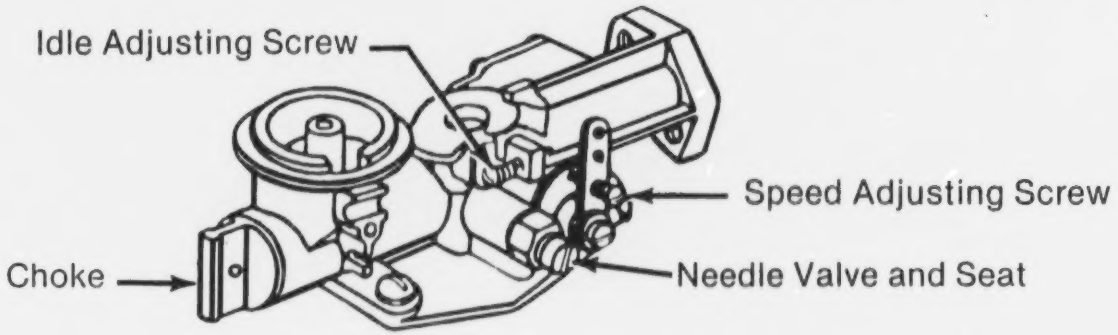

THROTTLE VALVE
IDLE SPEED NEEDLE VALVE
UPPER CARBURETOR BODY
FUEL INLET
FLOAT SEAT
FLOAT NEEDLE VALVE
FLOAT TANG
FLOAT
FLOAT
VENTURI
LOWER CARBURETOR BODY
PACKING NUT
MAIN FUEL NOZZLE
GASOLINE
AIR HORN
HIGH SPEED NEEDLE VALVE
CHOKE VALVE

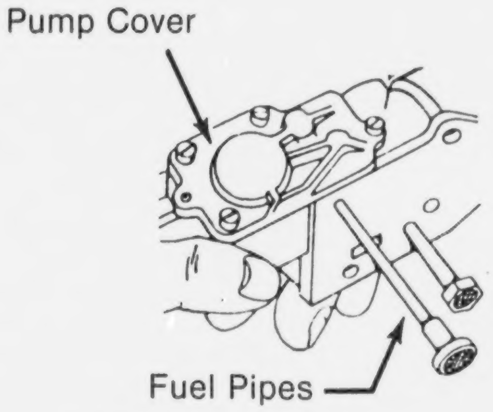
DIAPHRAGM-TYPE CARBURETOR

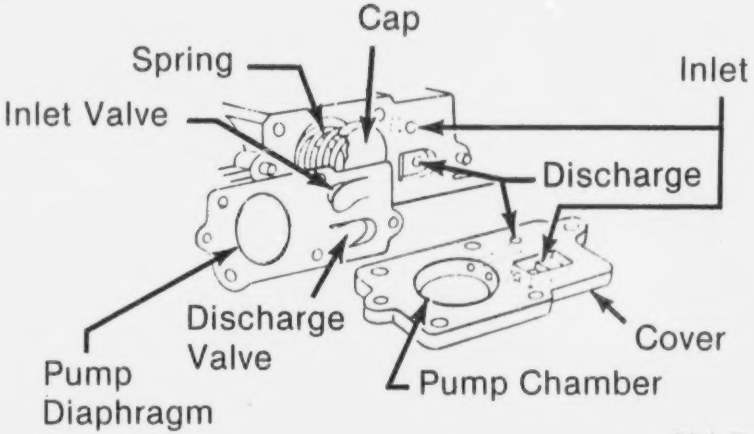

VENTURI
FUEL
FUEL VALVE OPEN
SPRING
ATMOSPHERIC PRESSURE
DIAPHRAGM
PISTON DOWN


FUEL
FUEL VALVE CLOSED
TO FUEL TANK
PISTON UP

Parts of a Diaphragm Carburetor


Idle Adjusting Screw
Speed Adjusting Screw
Choke
Needle Valve and Seat


Pump Cover
Fuel Pipes


Cap
Spring
Inlet
Inlet Valve
Discharge
Discharge Valve
Cover
Pump Diaphragm
Pump Chamber

TM-16

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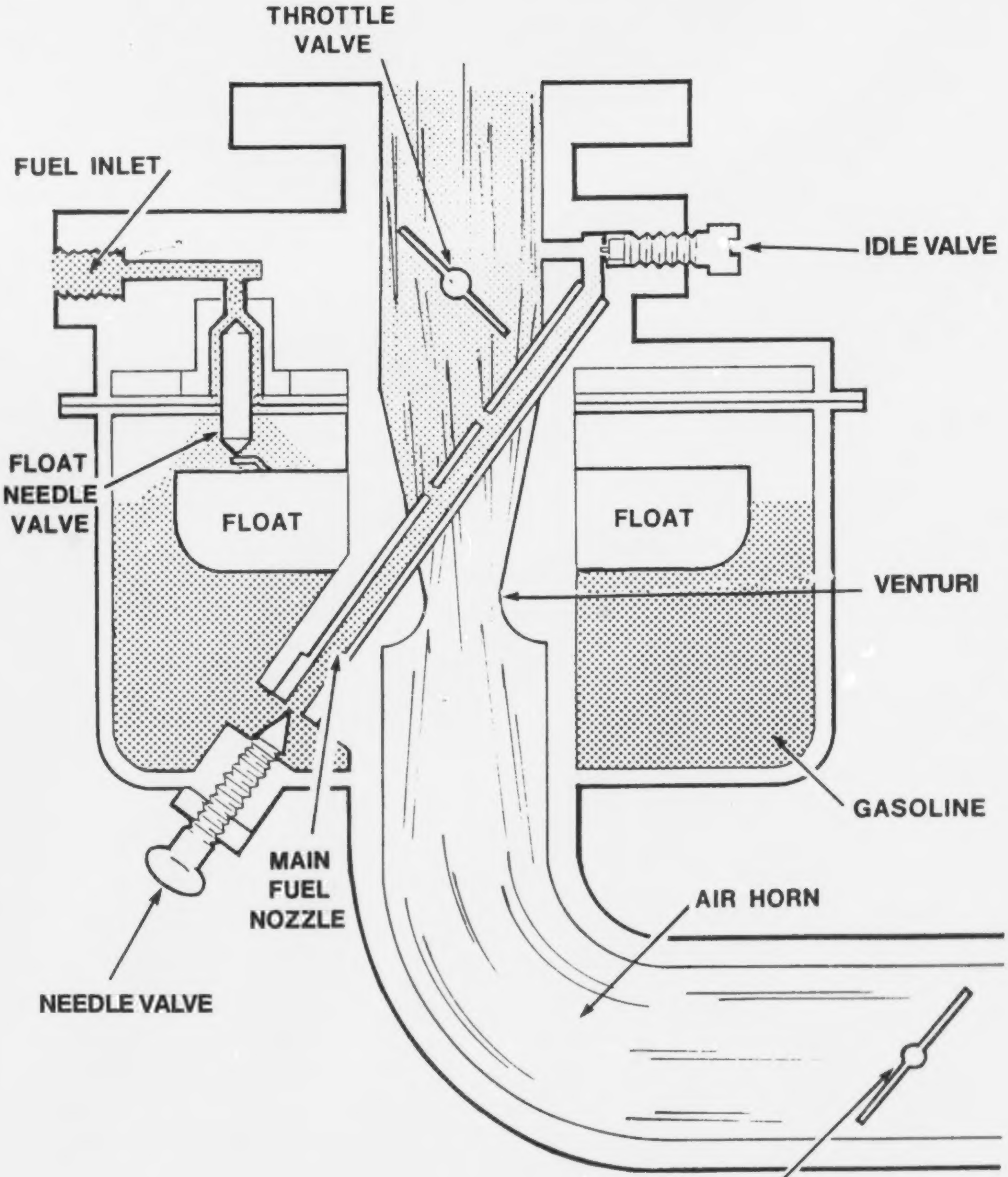
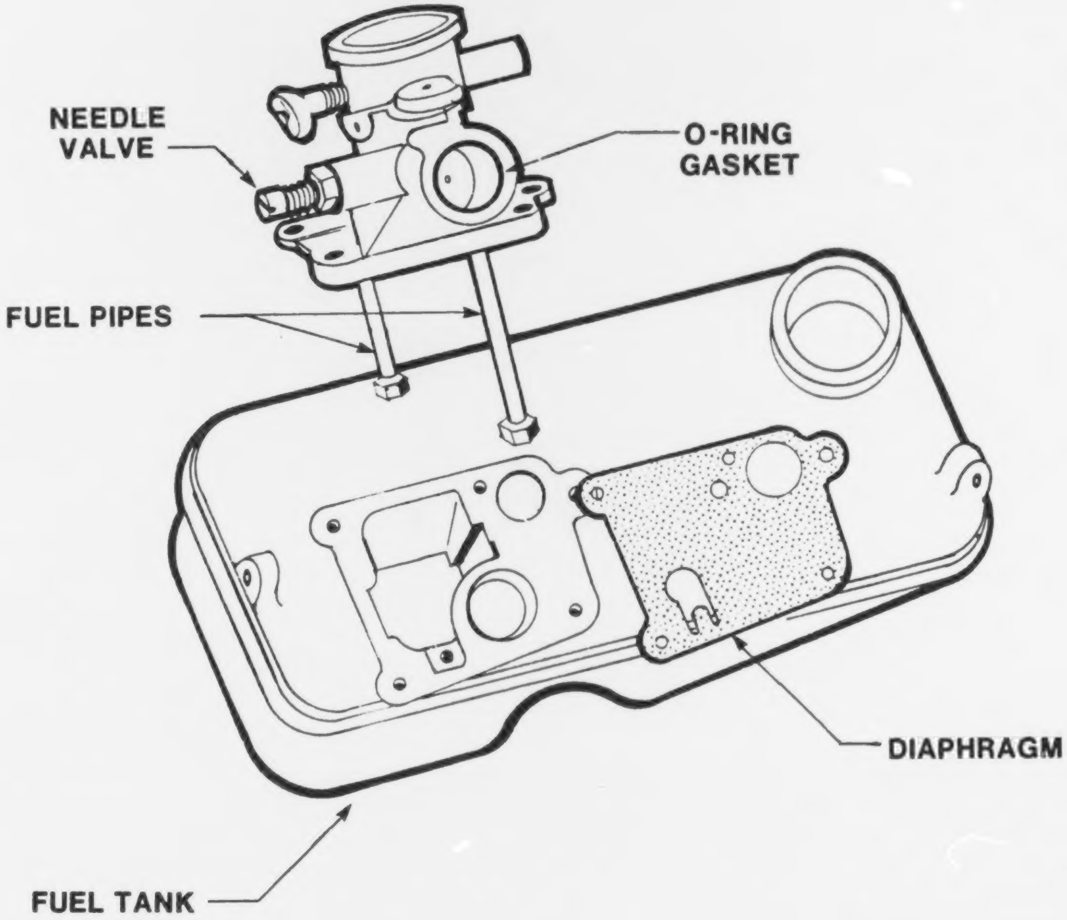
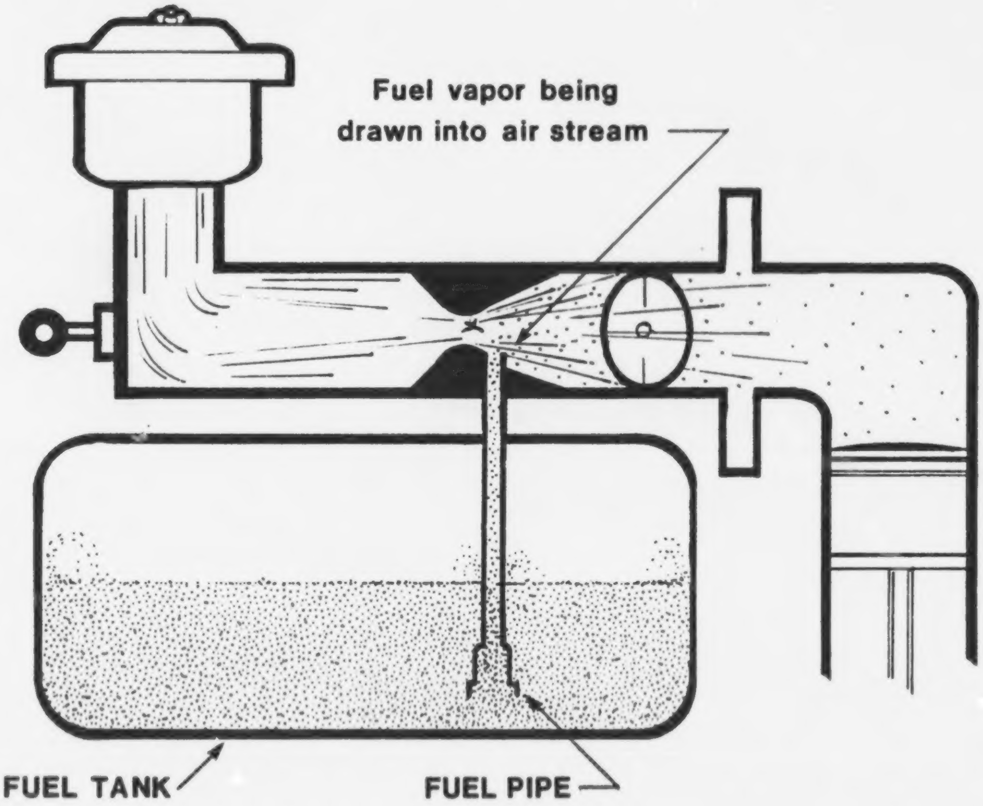
FLOAT-TYPE CARBURETOR


THROTTLE VALVE
FUEL INLET
IDLE VALVE
FLOAT NEEDLE VALVE
FLOAT
FLOAT
VENTURI
GASOLINE
MAIN FUEL NOZZLE
AIR HORN
NEEDLE VALVE
CHOKE VALVE

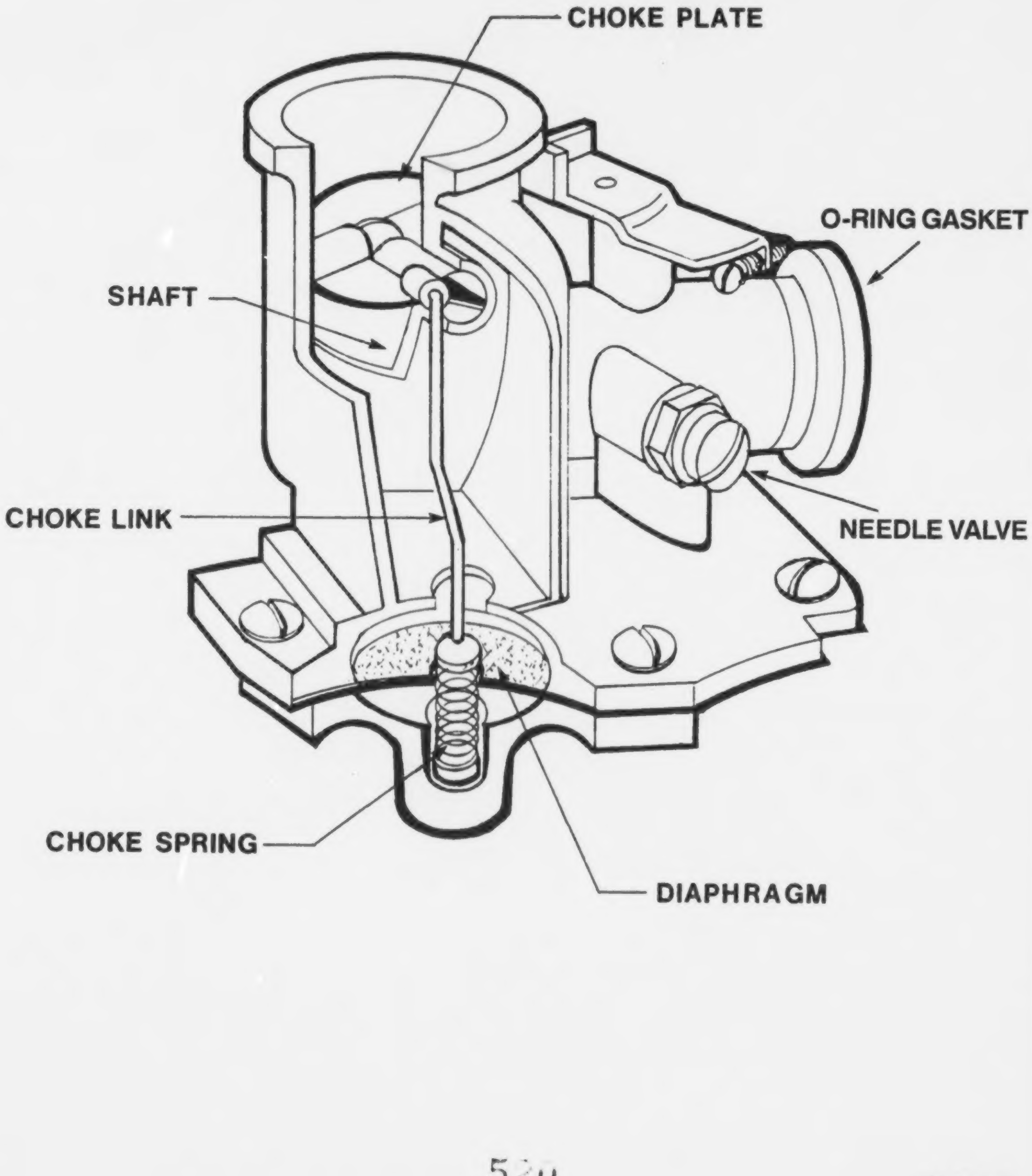
PARTS OF A SUCTION CARBURETOR WITH AN AUTOMATIC CHOKE


NEEDLE VALVE
O-RING GASKET
FUEL PIPES
DIAPHRAGM
FUEL TANK

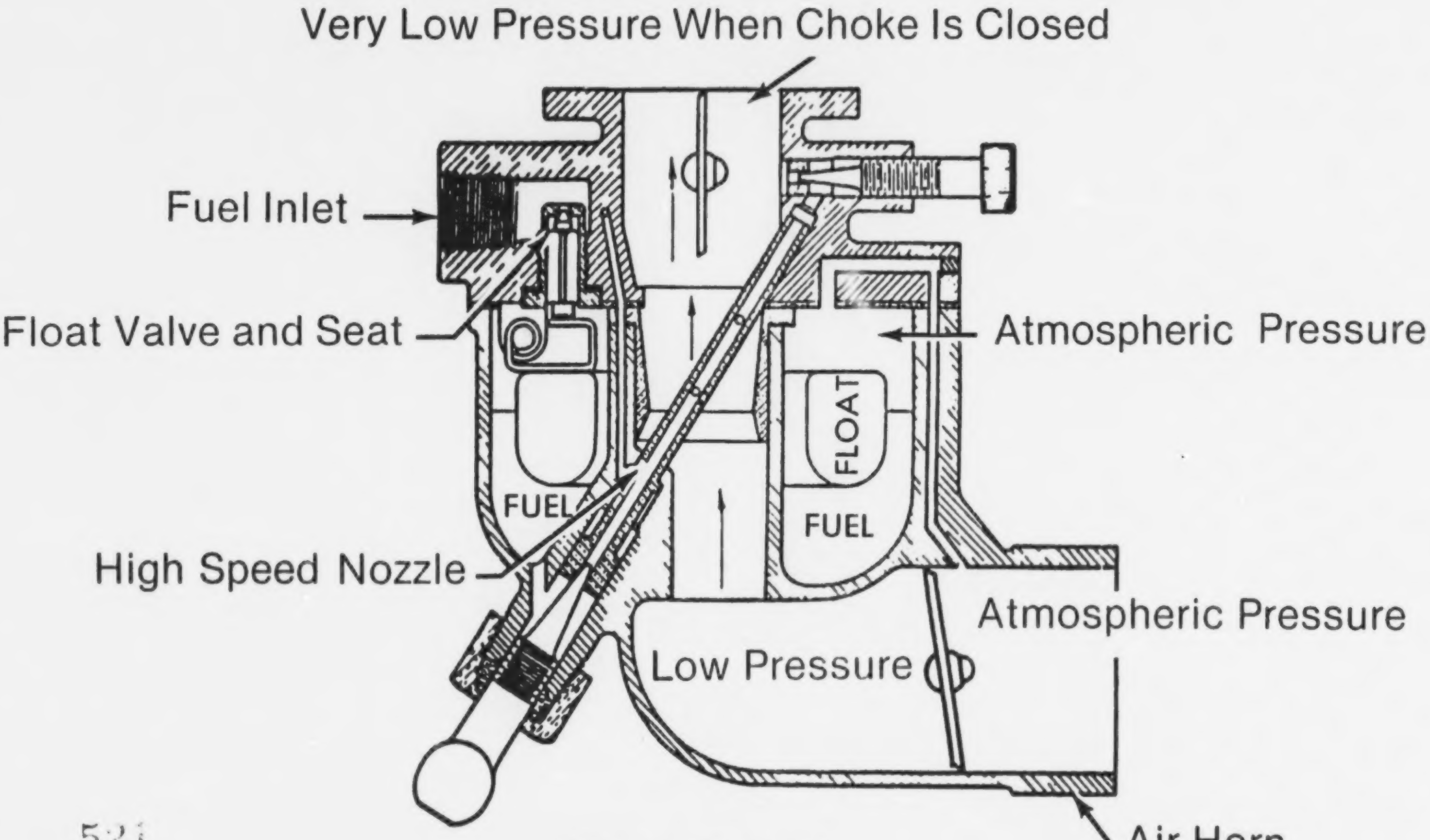
SUCTION-TYPE CARBURETOR


Fuel vapor being
drawn into air stream
FUEL TANK
FUEL PIPE

PARTS OF THE AUTOMATIC CHOKE

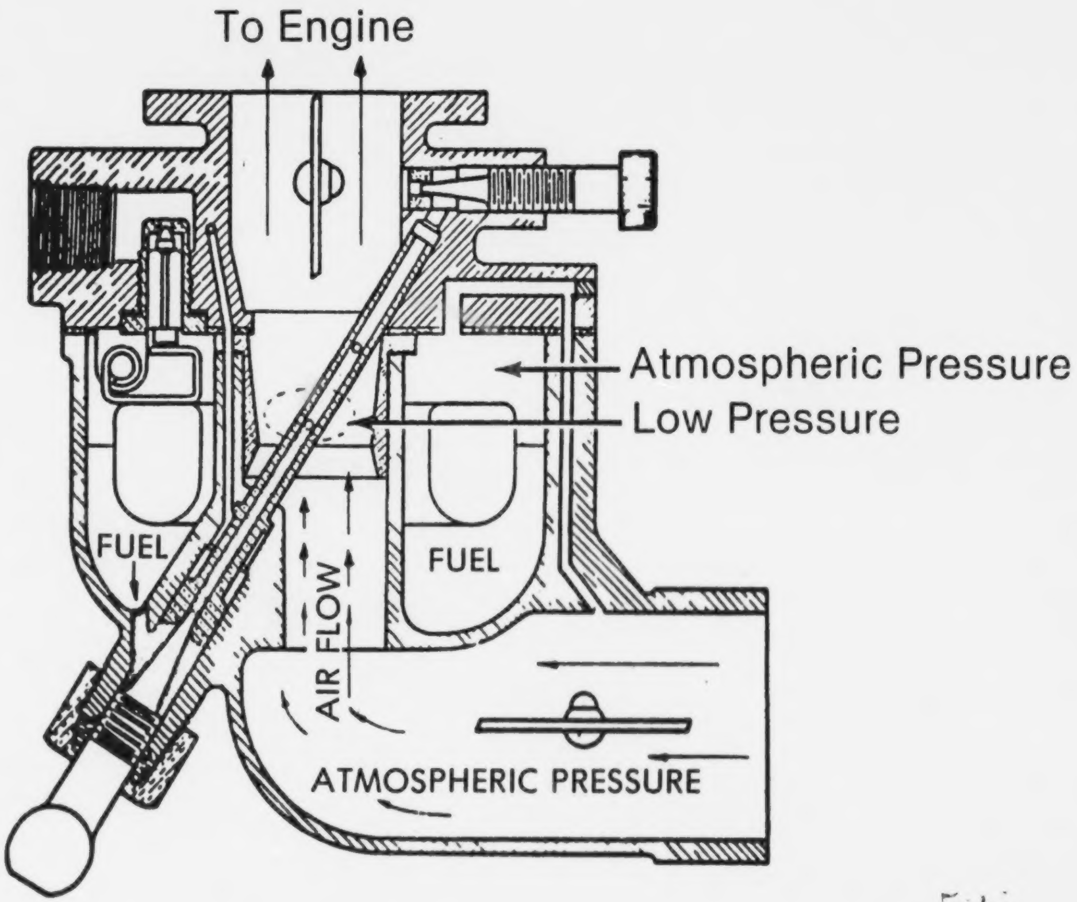

CHOKE PLATE
O-RING GASKET
SHAFT
NEEDLE VALVE
CHOKE LINK
CHOKE SPRING
DIAPHRAGM

The Choke System


Very Low Pressure When Choke Is Closed
Fuel Inlet
Float Valve and Seat
Atmospheric Pressure
FLOAT
FUEL
FUEL
High Speed Nozzle
Atmospheric Pressure
Low Pressure
Air Horn

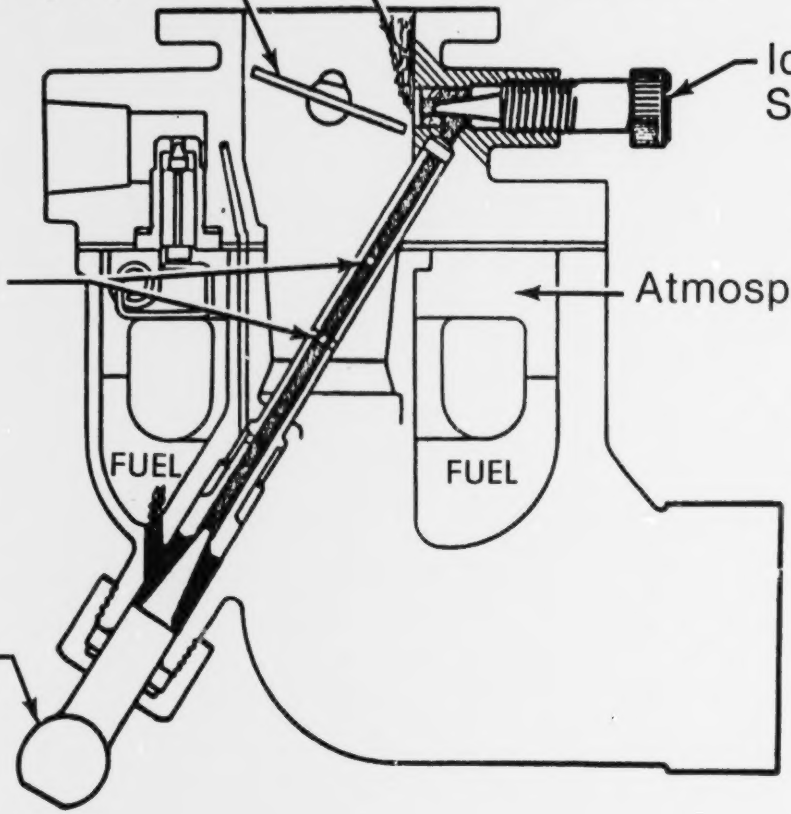
Choke Closed

The High Speed System


To Engine
Atmospheric Pressure
Low Pressure
FUEL
FUEL
AIR FLOW
ATMOSPHERIC PRESSURE

TM-22

The Idle System



Should Be Slightly Open

Low Pressure

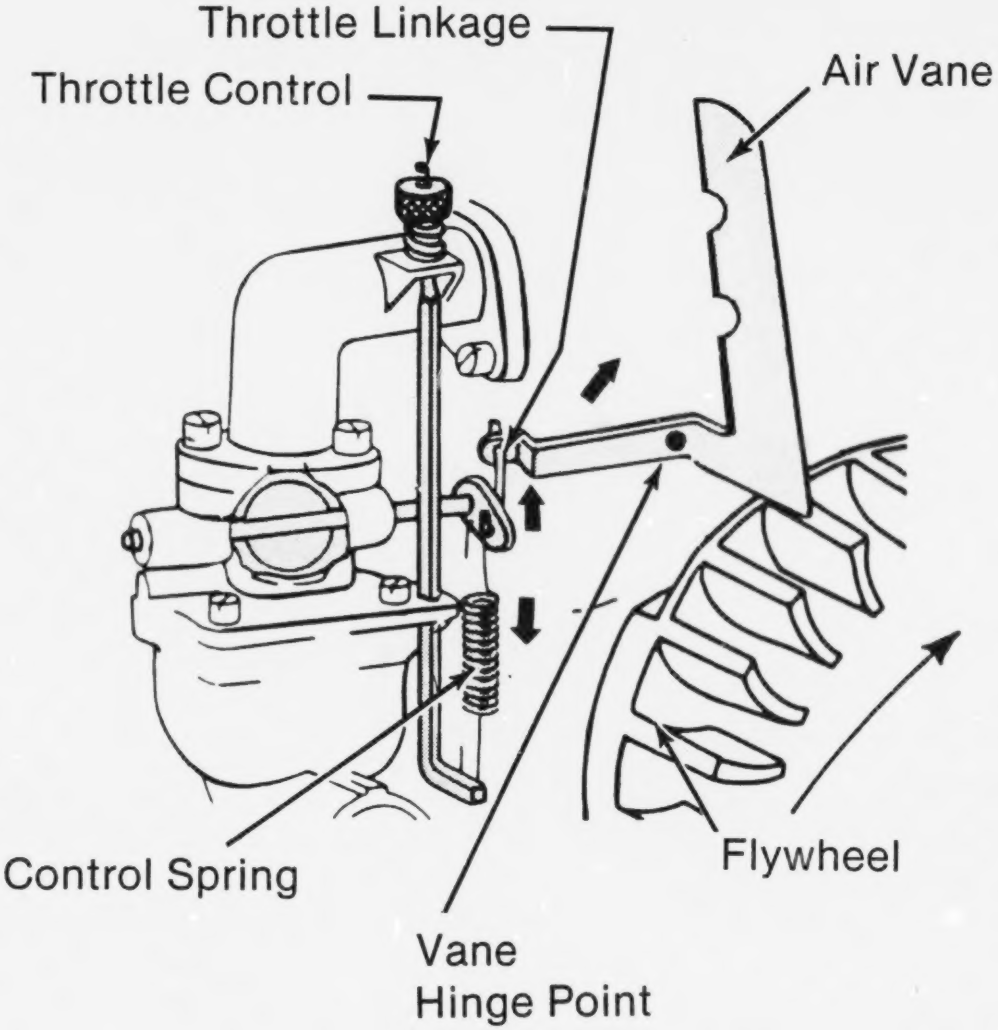
Idle Mixture Screw

Air Bleed Holes

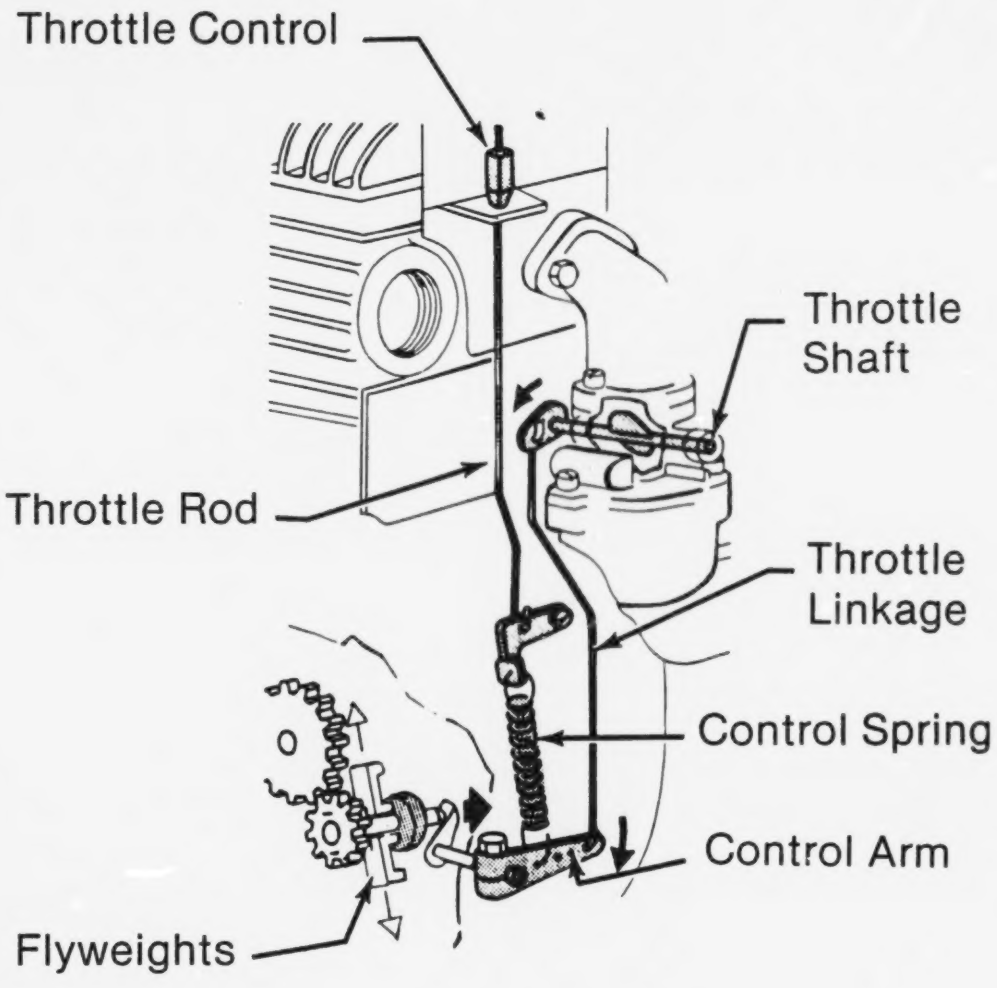
Atmospheric Pressure

Needle Valve

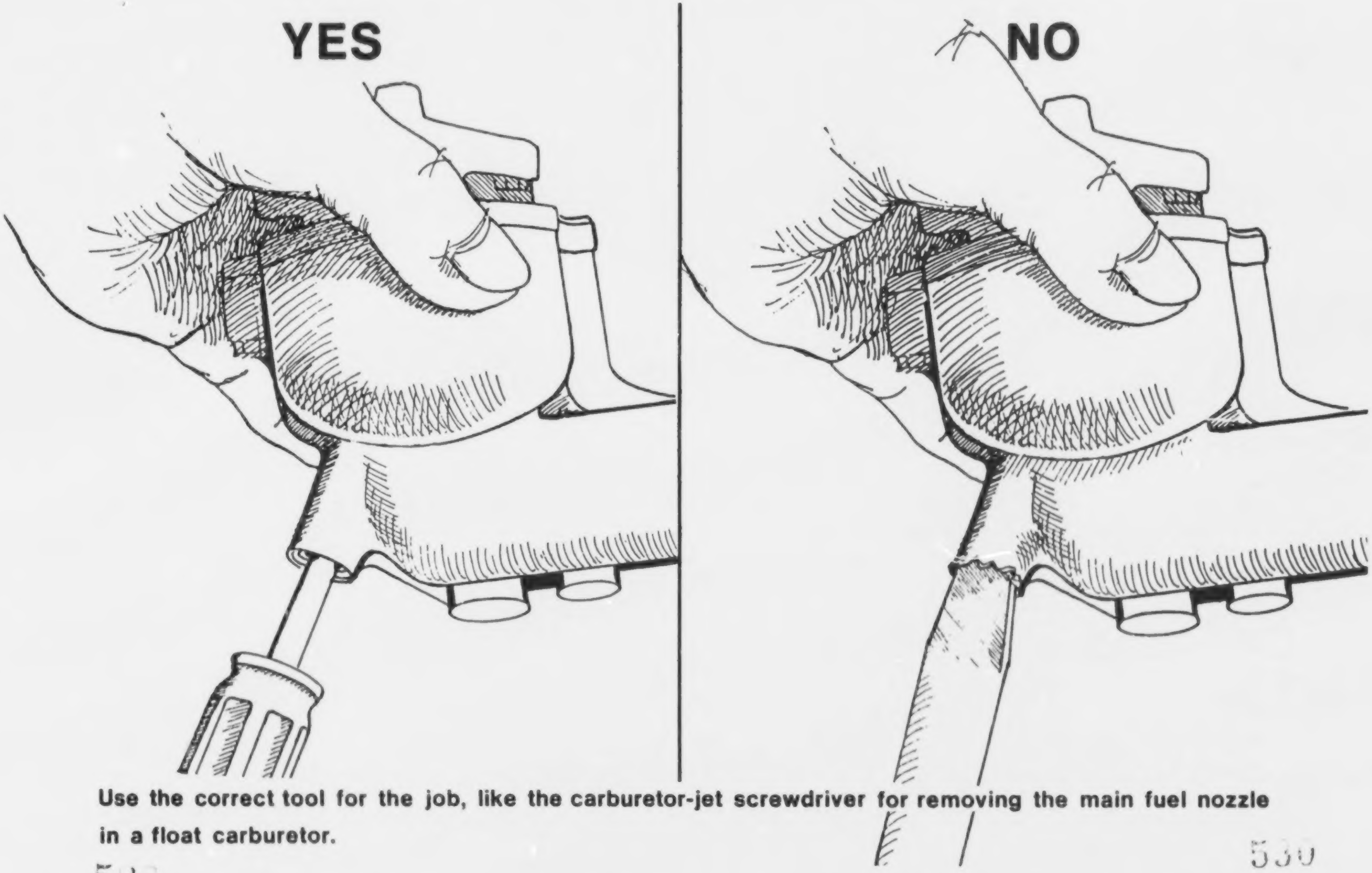
Components of an Air Vane Governor System


Throttle Linkage
Throttle Control
Air Vane
Control Spring
Flywheel
Vane
Hinge Point

Components of a Mechanical Governor System


Throttle Control
Throttle Shaft
Throttle Rod
Throttle Linkage
Control Spring
Control Arm
Flyweights

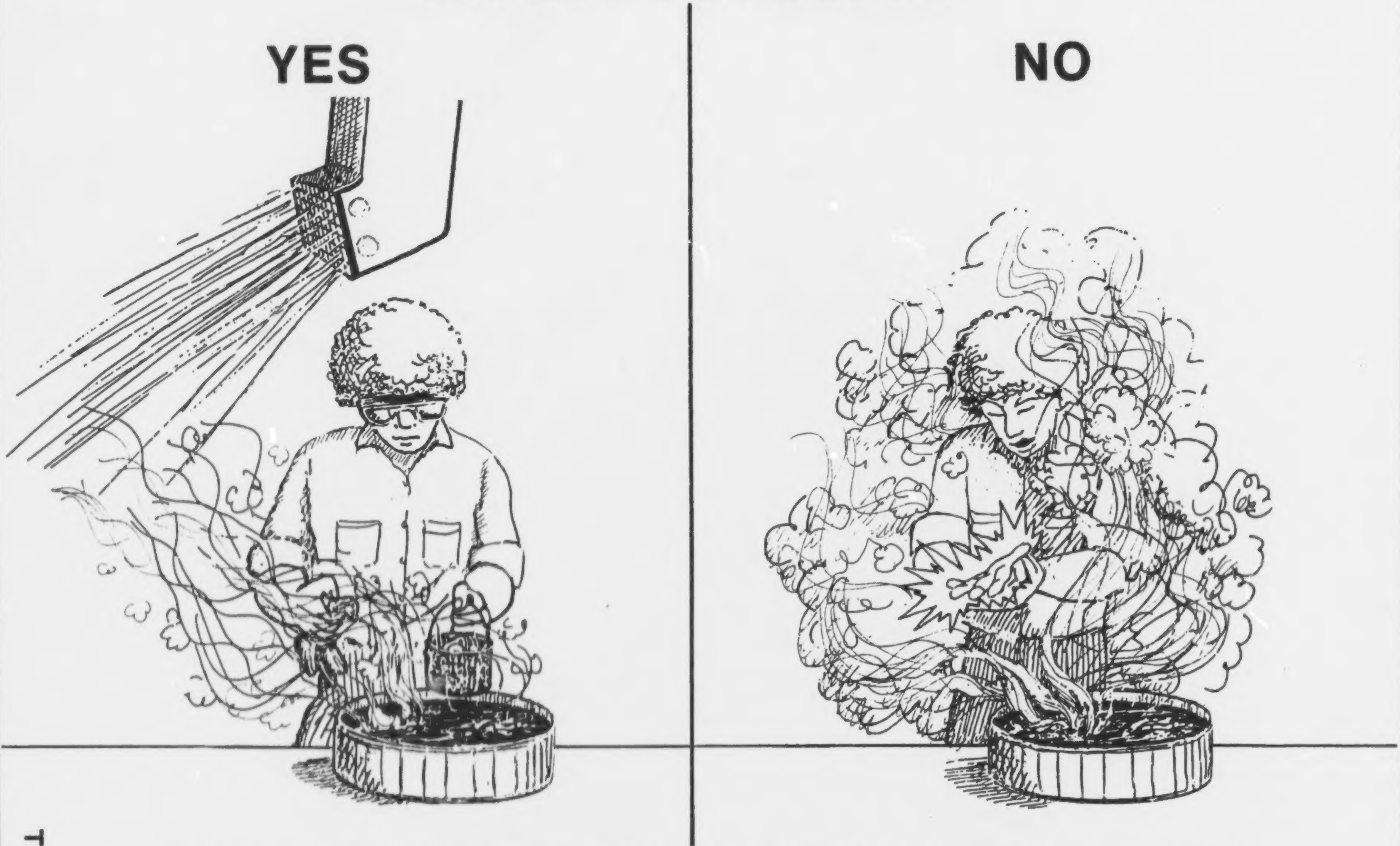
SAFETY TO FOLLOW



Use the correct tool for the job, like the carburetor-jet screwdriver for removing the main fuel nozzle in a float carburetor.

TM-26

SAFETY TO FOLLOW

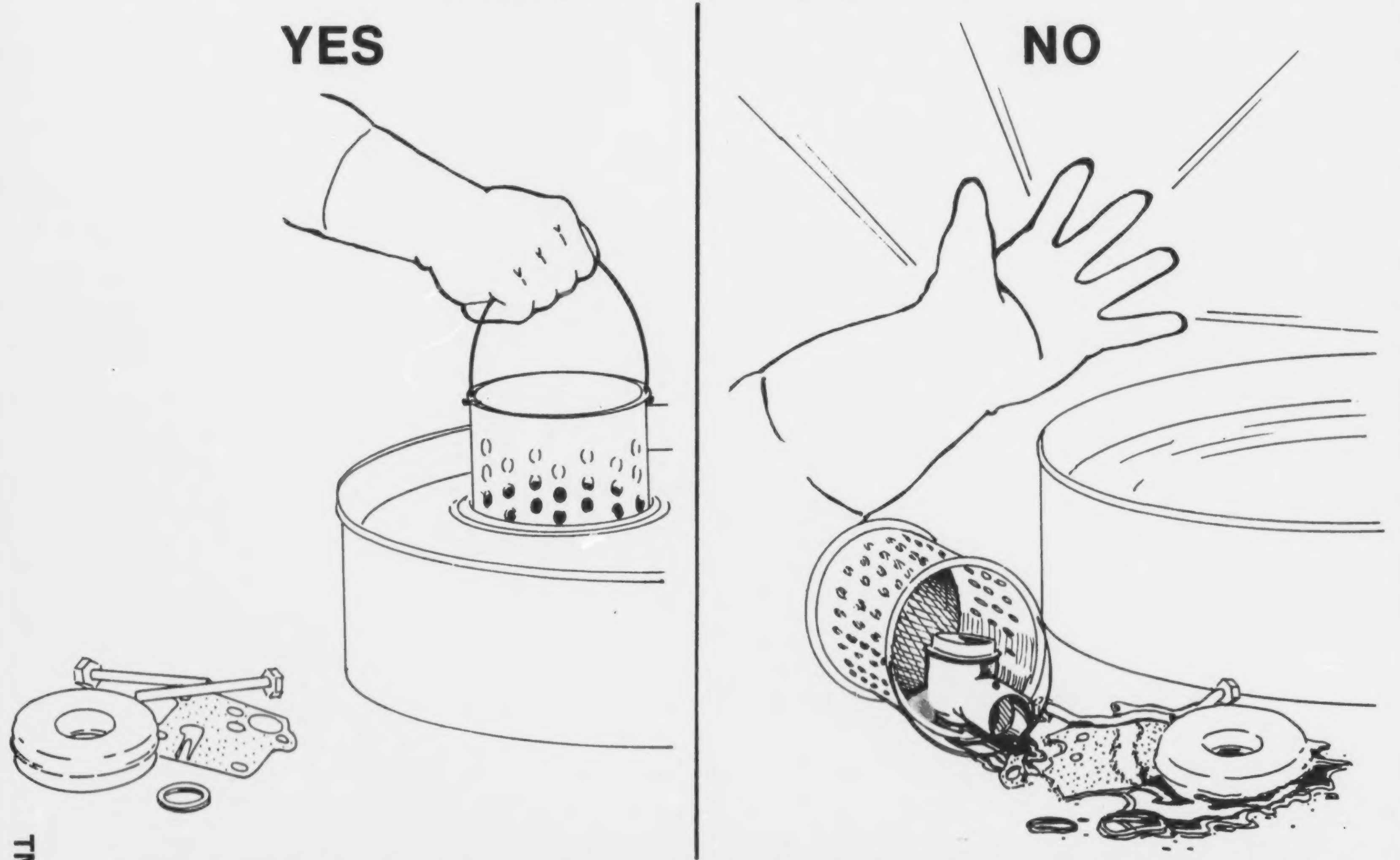


TM-27

When using carburetor cleaner, open a window or turn on the air in the shop and be careful not to get the cleaner on your skin or in your eyes. Carburetor cleaner can hurt you.

BEST COPY AVAILABLE

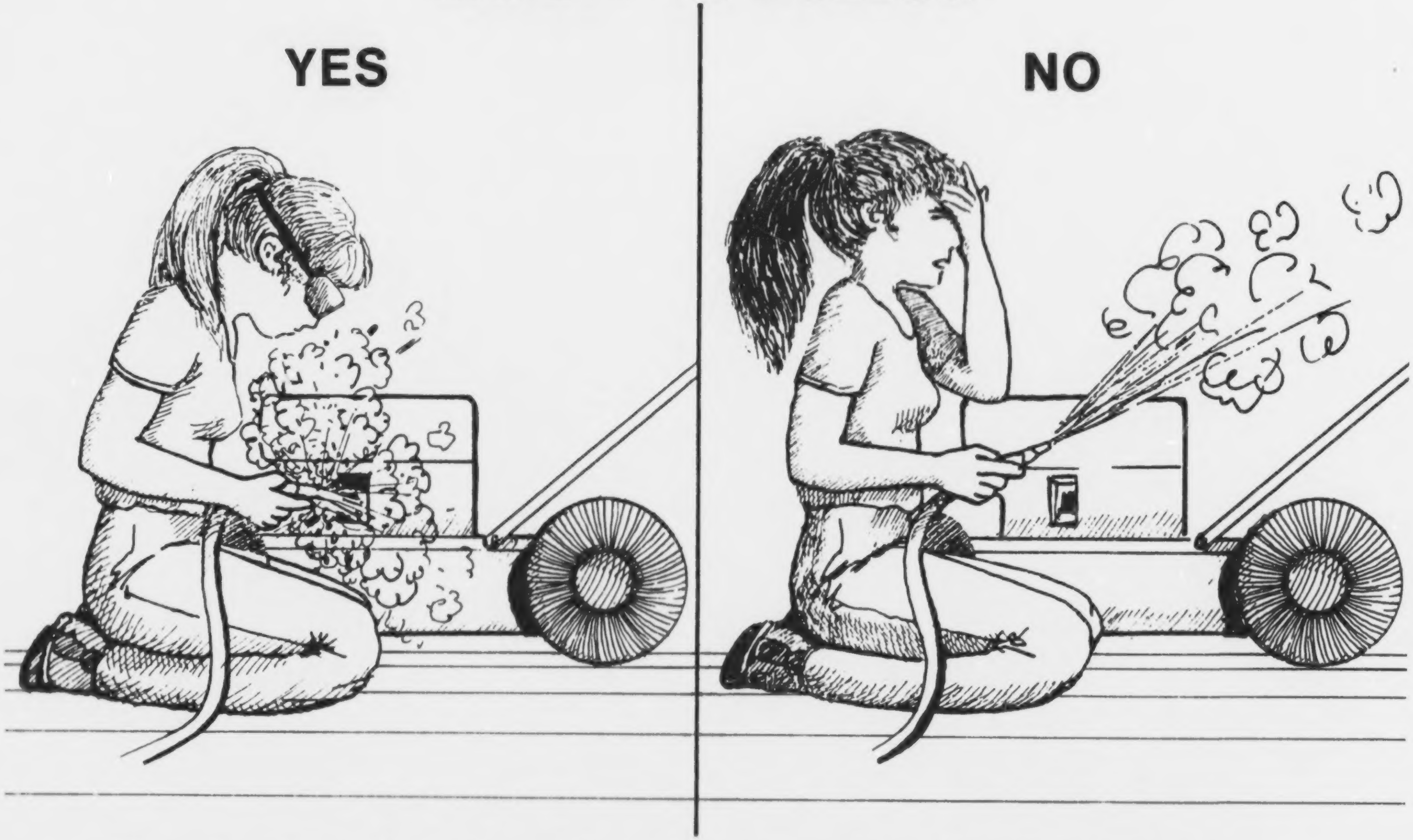
SAFETY TO FOLLOW



TM-28

Remove all gaskets and nylon parts on carburetors when soaking them in carburetor cleaner because these parts can melt or become brittle and break.

SAFETY TO FOLLOW

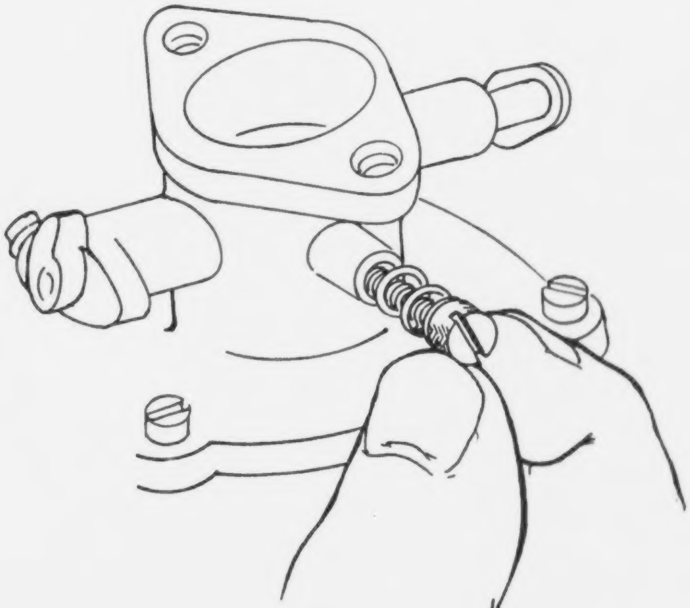


Wear safety glasses when using compressed air. The air could blow dirt from the engine parts into your eyes.

TM-29

SAFETY TO FOLLOW

YES



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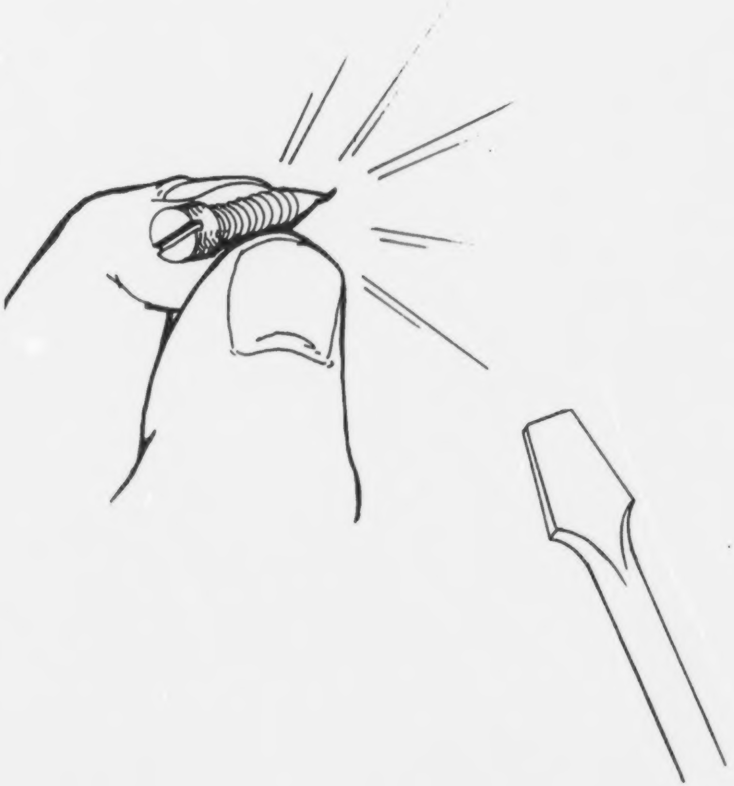
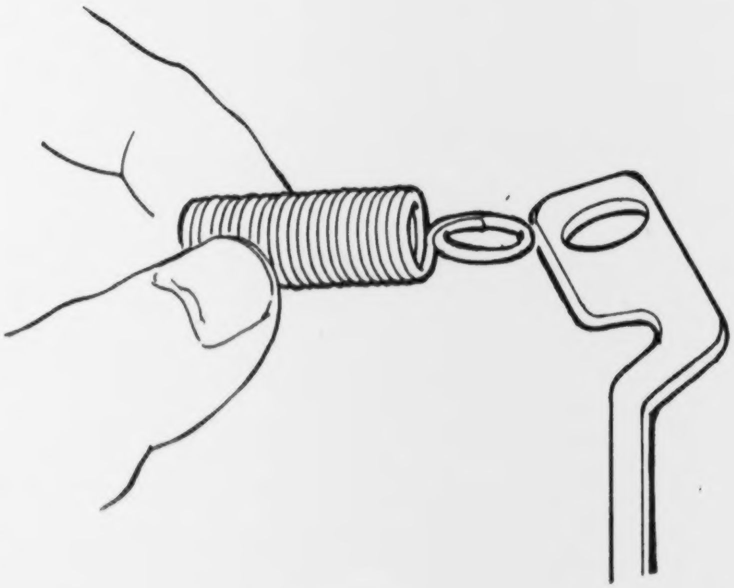


Replace carburetor needle valves just until they are seated and not any tighter. The tip ends of the needle valves could be easily damaged if they are overtightened.

TM-30

SAFETY TO FOLLOW

YES



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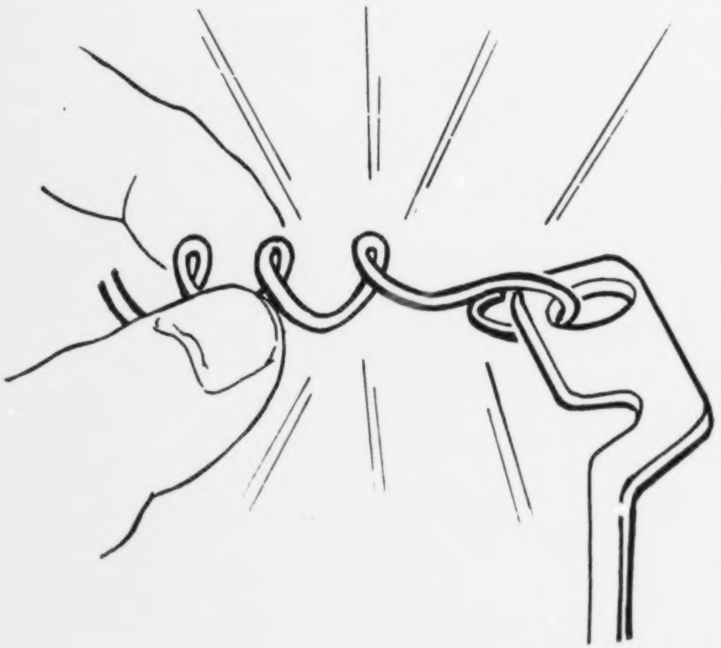
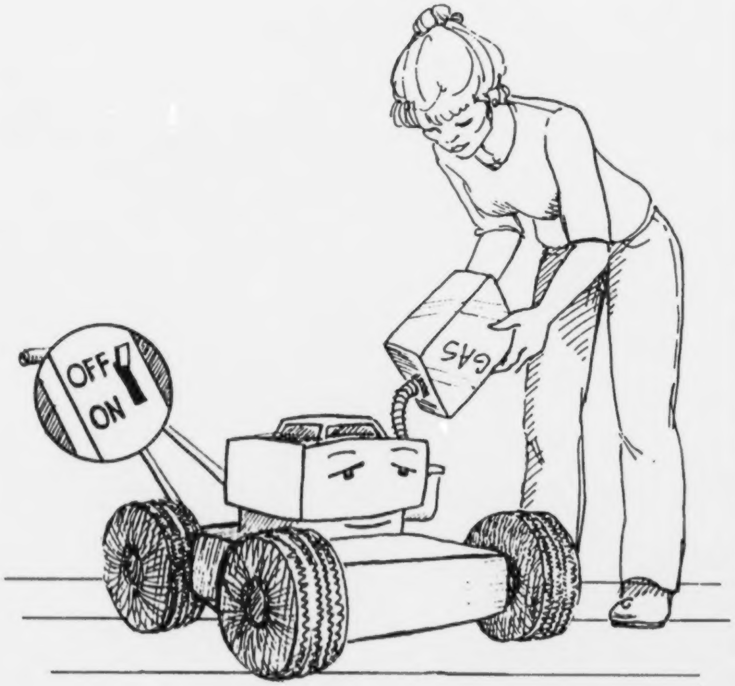


When removing a carburetor from an engine, carefully disconnect the governor spring and link so that they are not stretched out of shape. Bending or stretching them out of shape will change their shape length and cause the engine not to run properly.

TM-31

SAFETY TO FOLLOW

YES



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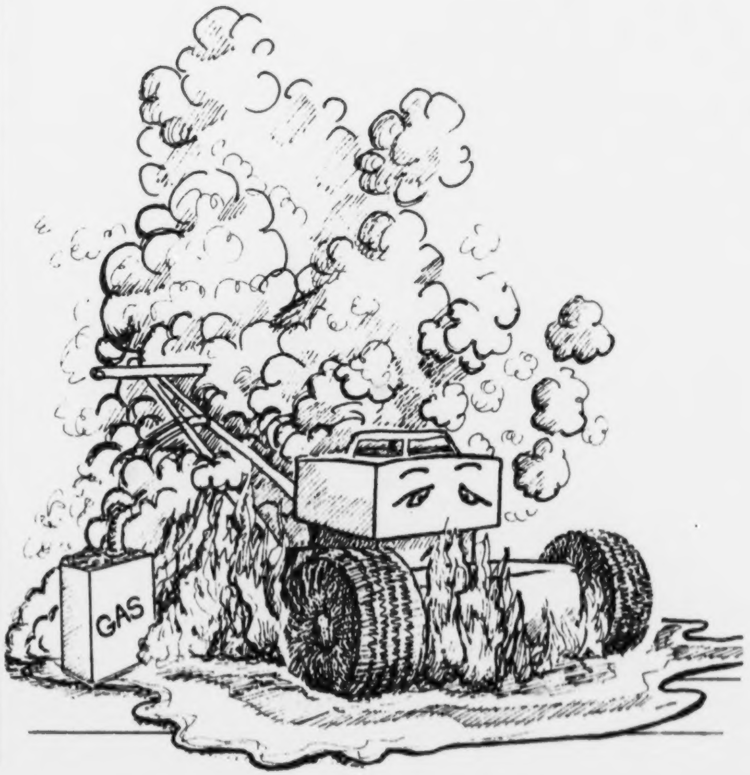


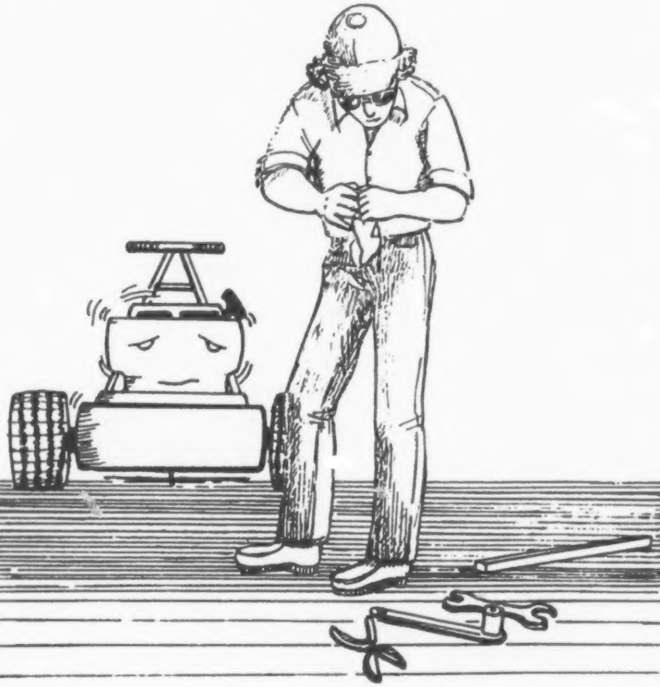
Always turn off the engine before filling the fuel tank. Gasoline can easily start a fire.

TM-32

BEST COPY AVAILABLE

SAFETY TO FOLLOW

YES



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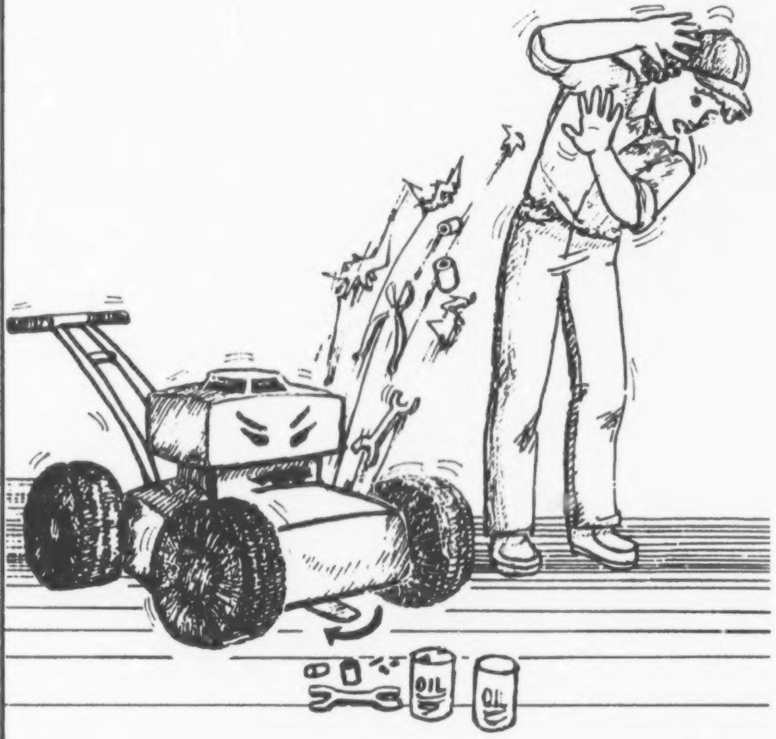

WHEN AN ENGINE IS RUNNING, KEEP TOOLS AWAY FROM MOVING PARTS.

ASSIGNMENT SHEET
SMALL ENGINE REPAIR

NAME ______________________________ **DATE** ________________

UNIT: Principles of Carburetion

TOPIC: Principles of Carburetion

DIRECTIONS: Read and answer the following questions in the space provided.

1. State the purpose of the fuel system.

2. Three types of fuel supply systems are
   a.
   b.
   c.

3. Two types of carburetors are ________________ and ______________.

4. Describe the venturi.

5. The needle valve serves what purpose?

6. Match the fuel system components.

______a. Is used as a reservoir for engine fuel
______b. Prevents dirt or foreign matter from entering the carburetor
______c. Mixes the proper proportion of fuel and air for a combustible mixture
______d. Carries the fuel from the fuel tank to the carburetor.
______e. Sheet of material flexible enough to permit vibration

1. Fuel line
2. Fuel tank
3. Carburetor
4. Pump diaphragm
5. Fuel filter

7. The engine part that mixes the air and fuel is the ____________________.

8. Explain the advantages of a diaphragm carburetor.

9. Explain the purpose of the choke.

10. Explain the function of the throttle.

11. Name the two types of governor systems.

12. Match the governor system components on the right with their correct purposes.

Air vane

______1. Connection between throttle control and throttle valve shaft

______2. Connects air vane to the throttle valve shaft

______3. Provides pneumatic pressure in relationship to engine RPM

______4. Senses air movement and open or closes throttle

______5. Regulates engine speed

a. Control spring

b. Flywheel

c. Linkage

d. Air vane

e. Throttle control

Mechanical

______1. Transfers the control adjustments to the control spring

______2. Provides tension to control arm

______3. Senses engine RPM and controls governor control arm

______4. Regulates the engine speed

______5. Connects the control arm to the throttle shaft

______6. Transfers flyweight/counterweight action to throttle link.

a. Flyweights/counterweight

b. Control arm

c. Control spring

d. Throttle linkage

e. Throttle rod

f. Throttle control

JOB SHEET

SMALL ENGINE REPAIR

NAME____ **DATE**________________

UNIT: Principles of Carburetion

TOPIC: Service an Air Cleaner

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(C), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to service an air cleaner correctly.

TOOLS AND EQUIPMENT:

Compressed air
Container of solvent and cleaning brush
Shop towels
Screwdriver
Clean engine oil
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to service the air cleaner properly.

PROCEDURES AND/OR TASKS: **Note:** *Use safety precautions.*

1. Disconnect and ground spark plug wire.
2. Remove air cleaner fasteners.
3. Remove air cleaner and cleaner cover.
4. Determine type of air cleaner element.
5. Service the air cleaner according to type.

Servicing the paper element air cleaner.

1. Paper elements can be cleaned by tapping lightly on a flat surface, or by using compressed air to force the dirt from the inside the filter out..
2. If paper element is damaged, replace it (check engine operator's manual).
3. Check top and bottom gasket surfaces of paper element for damage.
4. Install right side up when indicated.

Servicing the polyurethane element

1. Remove the element from the support screen.
2. Wash it thoroughly.
   Note: *Element should be washed in solvent or soap and water; never in gasoline.*
3. Squeeze any solvent or soap and water from the screen.
4. Re-oil the filter element with clean engine oil.
5. Squeeze any excess oil from the filter element.
6. Replace the filter element on the support screen.
   Note: *Be sure the element forms a seal around the top and bottom contact edges.*

Service the oil bath air cleaner

1. Set up tray and pour solvent in tray.
2. Remove wing nut and separate parts for cleaning.
   Note: *Dispose of old oil properly* .
3. Rinse air strainer and parts in clean solvent. Use brush if needed.
4. Shake excessive solvent from the air strainer.
5. Saturate the air strainer gauze with light oil and allow excess to drip off.
6. Wash the dirt and grit out of lower cup with brush and clean solvent.
7. Fill lower cup with fresh oil to correct level for type of engine.
8. Reassemble unit and install wing nut.
9. Tighten wing nut securely

10. Clean the filter body and cover before replacing.
11. Before replacing, be sure air cleaner and carburetor gasket are in good condition and in place.
12. Replace the air cleaner body.
13. Be sure air cleaner is in proper position.
14. Tighten air cleaner wing nut or bolt securely.
15. Avoid over-tightening the wing nut or bolt. This can cause warpage or improper operation of the choke.
16. Install any hoses to air cleaner as required.
17. Replace spark plug wire.
18. Have instructor check work.
19. Clean work area and replace tools to proper area.

III-2-JS-2

JOB SHEET
SMALL ENGINE REPAIR

NAME____________________________________ **DATE**________________

UNIT: Principles of Carburetion

TOPIC: Remove and Replace a Float Type Carburetor

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(C), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to remove and replace a float type carburetor correctly.

TOOLS AND EQUIPMENT:

Open end wrenches
Hand tool assortment
Tubing wrenches
Torque wrench
Shop towels
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to remove and replace the float type carburetor properly.

PROCEDURES AND/OR TASKS: Check manufacturer's manual for any specifications.
Note: *Use safety precautions.*

1. Disconnect and ground the spark plug wire.
2. Remove the air cleaner.
3. Disconnect the fuel line.
4. Use back-up wrench to avoid twisting the line.
5. Use container to catch gas.
6. Disconnect the throttle linkage.

7. Disconnect the choke control cable, if one is used.
8. Remove ignition ground wire, if one is used.
9. Remove the nuts and bolts that hold the carburetor.
10. Remove throttle linkage at this time. **DO NOT BEND**. Identify the correct locations.
11. Remove the old carburetor to manifold gasket.
12. Clean the gasket mounting surface.
13. Close the manifold opening to prevent material from entering the engine.
14. Install a new manifold to the carburetor gasket.
15. Set carburetor in place and start fasteners.
16. Replace throttle linkage in correct locations.
17. Tighten and torque carburetor fasteners.
18. Connect choke linkage.
19. Connect the ignition ground wire.
20. Connect the fuel line to the carburetor.
21. Tighten fuel line securely, using back-up wrench.
22. Replace air cleaner.
23. Connect spark plug wire.
24. Make sure all connections and accessories are secure.
25. Start engine and check for leaks.
26. Make the idle air mixture and idle speed adjustments as required by engine manual.
27. Have instructor check work.
28. Clean work area and replace tools to proper area.

JOB SHEET

SMALL ENGINE REPAIR

NAME____ **DATE**_______________

UNIT: Principles of Carburetion

TOPIC: Repair Leak In Steel Fuel Tank

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(C), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to repair a leak in a steel fuel tank correctly.

TOOLS AND EQUIPMENT:

Open end wrenches
Slot-head screwdriver
Shop towels
Cleaning solvent
Solder gun
40-60 lead solder
Fuel container
Safety glasses
Container large enough for gas tank
Water to fill container
Compressed air
Spray paint

GENERAL INSTRUCTIONS: Follow procedures to repair a leak in a steel fuel tank properly.

PROCEDURES AND/OR TASKS: Note: *Use safety precautions.*

CAUTION: **Never apply heat to a tank that contains fumes. It will explode.**

1. Remove the tank.
2. Soak tank in container of water to remove liquid fuel and gas fumes.
3. After tank is full of water, let it stand for a few minutes.
4. Clean around the hole.

5. Solder the hole or crack using a 40-60 lead solder.
6. Refill tank with water and check for leaks.
7. If no leaks are found, drain tank and dry as soon as possible to prevent rust. If available, use forced air to dry tank.
8. Keep tank in a clean area.
9. Do not allow dirt or trash inside tank.
10. Repaint outside of tank.
11. Reinstall strainer.
12. Reinstall tank on engine.
13. Connect fuel lines and tighten.
14. Fill with fuel.
15. Replace fuel cap.
16. Have instructor check work.
17. Clean work area and replace tools in proper location.

JOB SHEET

SMALL ENGINE REPAIR

NAME______________________________ **DATE**______________

UNIT: Principles of Carburetion

TOPIC: Replace Carburetor Diaphragm in a Pulsa-Jet Style with Automatic Choke

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2) (C), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to replace the diaphragm in a pulsa-jet carburetor with an automatic choke correctly.

TOOLS AND EQUIPMENT:

Clean solvent
New O ring
Parts container
Gasoline
Phillips screwdriver
Flat tip screwdriver
Socket set
Feeler gauge
6-in. steel ruler
Shop towels

GENERAL INSTRUCTIONS Follow procedures to replace the diaphragm in a pulsa-jet carburetor with an automatic choke properly.

PROCEDURES AND/OR TASKS: Check manufacturer's manual for specifications.

Note: *Use proper safety precautions.*

1. Remove and ground the spark plug wire.
2. Use a flat tip screwdriver to remove the mounting bolt and air cleaner from the carburetor and set aside.
3. Loosen the throttle cable clamp bolt and remove the cable from the throttle.

4. Remove the breather hose that is connected to the carburetor tube and crankcase breather tube and set it aside. Be careful not to tear hose.

5. Remove the smaller mounting bolt with a 7⁄16-in. socket and ratchet. Put the bolt and washer in parts container.

6. Remove the larger mounting bolt with 1⁄2-in. socket, extension, and rachet, and put bolt and washer in parts container.

7. Loosen the carburetor and fuel tank from the crankcase intake tube.
CAUTION: Be careful not to bend governor link or stretch the spring loop.

8. Unhook the governor spring from the throttle by twisting the spring end loop from the throttle hole carefully.

9. Slightly tilt carburetor and fuel tank toward the engine and unhook the governor link from the throttle hole.

10. Remove carburetor and tank and set them on your workbench.

11. Remove the automatic choke link cover and bolt, using a flat tip screwdriver. Set cover, bolts, and gasket in parts container.

12. Pull the choke link from the choke shaft carefully.

13. Using a flat tip screwdriver, remove the mounting bolts holding the carburetor to the fuel tank.

14. Some carburetors will have a mounting bolt inside the carburetor and underneath the choke plate. Remove this bolt with a Phillips screwdriver.

15. Place all bolts and washers in parts container.

16. Using a flat tip screwdriver, separate the carburetor from the fuel tank. **Be careful not to damage fuel pipe and choke linkage.**

17. Remove the fuel pump spring and cap between the carburetor and diaphragm. Place spring and cap in parts container.

18. Remove old diaphragm from the fuel tank and place in the trash.

19. Check the O ring gasket on the carburetor to see if it is brittle, torn, or pulled out of shape. If so, replace with a new one.

20. Using a shop towel, wipe off any dirt or grease from the bottom of the carburetor.

21. Wipe any dirt from the top of the fuel tank.

22. If the carburetor and tank are very dirty, soak them in carburetor cleaner.

23. Check the fuel tank top for warpage. Place a straightedge across the middle area on top of the tank.

24. Try to fit a .002-in. feeler gauge between the straightedge and the middle area of the fuel tank top. If tank is flat, gauge will not fit. If tank is warped, replace with new tank.

25. To install a new diaphragm, place the automatic choke spring into the plastic lock on the bottom of the new diaphragm. Be careful not to stretch the spring.

26. Place the diaphragm on the fuel tank carefully and match the holes in the diaphragm with the openings on the fuel tank. Fit the choke spring into the fuel tank spring pocket.

27. Place the fuel pump spring and cap over the round recess on top of the diaphragm.

28. While holding the automatic choke link, place the carburetor on top of the diaphragm carefully.

29. Fit the fuel pipes through the two holes on the diaphragm. Fit the choke link on the diaphragm through the link hole on the carburetor.

30. Using the Phillips screwdriver, tighten the mounting bolt that goes inside the carburetor and under the choke plate securely.
    Note: *Some carburetors may not have this bolt.*

31. With your fingers, thread the other mounting bolts down two turns. Do not tighten until automatic choke is assembled.

32. To assemble the automatic choke, hold the choke plate closed with your finger and place the choke link into the choke shaft.

33. Open the choke plate so that the mounting bolts can be tightened.

34. Alternately tighten the mounting bolts in a staggered sequence in order to prevent bending the fuel tank or damaging the carburetor.

35. Move the choke plate to a normal position.

36. Replace the automatic choke link gasket and cover. Tighten the cover bolt with the flat tip screwdriver.

37. Holding the carburetor and fuel tank at an angle next to the crankcase, hook the governor link to the throttle.

38. Move the throttle to the left and fit the carburetor onto the crankcase intake tube. Be careful not to bend the O ring gasket in the carburetor.

39. Twist the governor spring onto the throttle carefully. Be careful not to stretch or bend the spring or loop end out of shape.

40. Use a 7/16-in. socket and ratchet to replace the small mounting bolt that holds the carburetor and fuel tank to the engine.

41. Use a 1/2-in. socket, extension, and ratchet to replace the larger mounting bolt.

42. Pinch the two ends of the breather hose together and fit onto the carburetor and breather tubes.

43. Hook the throttle cable onto the throttle. With a flat tip screwdriver, tighten the throttle cable and bolt.

44. Replace the air cleaner and bolt to top of carburetor.

45. Replace the spark plug wire.

46. Fill the fuel tank 1/2-in. full with gasoline. *Never fill the fuel tank while engine is running.*

47. Crank the engine. Let run about 2 minutes to warm up. (Be sure tools, materials, and feet are away from moving engine parts.)

48. Adjust the carburetor or throttle so that the sound of the engine is normal.

49. Have instructor check work.

50. Clean work area and return tools to proper area.

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III-2-JS-5

JOB SHEET

SMALL ENGINE REPAIR

NAME________________________________ DATE______________

UNIT: Principles of Carburetion

TOPIC: Service a Two-Piece Flo-Jet Carburetor

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2) (C), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to service the two-piece flo-jet carburetor correctly.

TOOLS AND EQUIPMENT:

7/16-in., 1/2-in. combination open end wrench
Cleaning pan with water
Carburetor cleaner and basket
Steel straightedge scale
Iron bar
Feeler gauge
Phillips screwdriver
Flat tip screwdriver
Needle nose pliers
Carburetor jet screwdriver
Combination pliers
Compressed air
Safety glasses
Carburetor repair kit
Hose clamp pliers
Parts container

GENERAL INSTRUCTIONS: Follow procedures to service the two-piece flo-jet carburetor properly.

PROCEDURES ANDOR TASKS: Check manufacturer's manual for specifications.
Note: *Use proper safety precautions.*

1. Remove spark plug wire.
2. Close the fuel shut-off valve by turning the thumb screw until it is tight. If throttle cable is connected to the engine, disconnect it.
3. Use hose clamp pliers to remove fuel hose clamp on the carburetor.

4. Twist and pull the fuel hose off the carburetor carefully.

5. Pull the crankcase breather hose off the air cleaner tube gently.

6. Remove air cleaner wing nut, cover, and foam element, and set these aside.

7. Use a large Phillips screwdriver to remove the two screws which join the carburetor to the intake manifold.

8. Use a 7⁄16-in. open-end wrench to remove the bolt and brace on some engines.

9. When the carburetor is loose, tilt it toward the engine and unhook the governor link on the throttle shaft.

10. Unhook the automatic choke link on the choke valve.

11. Remove the air cleaner tube from the carburetor carefully, and set the carburetor on the workbench.

12. To check the upper carburetor body for warpage, find the space between the upper and lower bodies at the air vent base, just below the idle valve.

13. Try to fit a .002-in. feeler gauge into this space.

14. To check the throttle shaft and bushing for wear, place a short iron bar between the throttle shaft and upper carburetor body.

15. Hold the throttle shaft down on the iron bar. Find a proper-sized feeler gauge that will fit between the shaft and bar. **Write down this size.**

16. Hold the throttle shaft up and again find a proper-sized feeler gauge that will fit between the shaft and bar. **Write down this size.**

17. Subtract these two sizes. The difference should not be over .010-in. (If it is, rebush the throttle shaft, replace the upper carburetor body, or both.)

18. To disassemble the carburetor, remove the idle needle valve. Place the idle valve and its spring in parts container.

19. Loosen the packing nut and high speed needle valve with the 7⁄16-in. open end wrench. Remove the packing nut and needle valve together. Put in parts container.

20. Check tip ends of the two needle valves for damage and wear. (If the tips have worn thin or are damaged, replace them with new ones.)

21. Remove the main fuel nozzle with the carburetor jet screwdriver carefully. The nozzle is found inside the lower carburetor body where the high speed needle valve is located.

22. Check the fuel nozzle for dirt and damage. Make sure all the holes are open and clear. Set the nozzle aside in parts container.

23. Remove mounting bolts and washers holding the upper and lower carburetor bodies together, and place them in parts container.

24. Separate the upper body from the lower body gently.
CAUTION: The float hinge pin which holds the float in place on the upper body may fall out. Be careful not to drop the float and pin.

25. If the pin did not fall out, remove it with the needle nose pliers and place in parts container. Set the lower body aside.

26. Remove the float and float valve carefully. Hold the float near your ear and shake to determine if it has gasoline inside. If float is crushed or has gasoline inside, it must be replaced with a new one.

27. Remove the float valve by slipping the spring clip off the tang. Place old float in trash. Connect the new valve onto the float tang. Place them in parts container.

28. Remove gasket from the upper carburetor body and place in trash.

29. Check the float valve seat on the upper carburetor body for damage.
Note: *This seat is pressed in and only needs replacement if it has nicks or cuts or if the float needle valve is replaced.)*

30. Clean the carburetor parts of dirt and buildup. First, place the parts in a carburetor cleaner basket.
CAUTION: Be sure floats, gaskets, and rubber parts are removed. Cleaner will make the rubber parts brittle.

31. Put the basket in the carburetor cleaner and gently move it up and down. Allow the parts sit in the cleaner for no more than 30 minutes.

32. After 30 minutes, remove basket from cleaner. Rinse parts in the basket thoroughly with water.

33. Dry parts one at a time with compressed air. Be sure to blow out all the holes in the carburetor bodies.
CAUTION: Always wear safety glasses or shield.

34. When parts are dry, put a new carburetor gasket on the upper carburetor body. Place the float and float valve carefully on the top of the gasket.

35. Lift up the float slightly (this will help to align the hinges). Push the float hinge pin through the hinges with your fingers carefully.

36. To check the float level, place a straightedge across float from hinge to opposite side. Measure the distance between gasket and straightedge on both sides of float. (Distance should be the same on both sides.)

37. If the distance is not the same on both sides, the float is not parallel to the carburetor. Adjust by bending the float tang until both sides are parallel.

38. To put the carburetor back together, place the lower carburetor body on the upper carburetor body.
CAUTION: Do not damage the float.

39. Fasten the two bodies together with the mounting bolts.

40. Replace the main fuel nozzle using the carburetor-jet screwdriver.

41. Using your fingers only, replace the idle speed needle valve until it is seated.
CAUTION: Do not over tighten because it could damage the tip end.

42. Back off the idle valve ¾-in. turn.

43. Replace the packing nut with the high speed needle valve in it, and seat the high speed needle valve.

44. Back off the high speed needle valve 1½ turns. Do not tighten the packing nut.

45. Push the air cleaner tube onto the carburetor.

46. Hook the automatic choke link on the choke valve.

47. Tilt the carburetor near the engine, and hook the governor link onto the throttle shaft.

48. Place a new intake manifold gasket on top of the carburetor.

49. Fit the carburetor under the intake manifold, making sure the gasket stays in place.

50. Tighten the two mounting screws on the intake manifold using a Phillips screwdriver.

51. Replace bolt and brace on the bottom of the carburetor with the 7⁄16-in. wrench.

52. Push the crankcase breather hose onto the air cleaner tube.

53. Push the fuel hose onto the carburetor. Use the pliers to fit the hose clamp over the fuel hose and carburetor.

54. Replace the air cleaner element, cover, and wing nut.

55. Open the fuel shut-off valve. Check the carburetor for leaks.

56. Replace spark plug wire and throttle cable.

57. Crank the engine and let it run for about 2 minutes.

58. Adjust carburetor until the engine idles smoothly and then accelerates to half speed without hesitation or sputtering.

59. Have instructor check work.

60. Clean work area and replace tools to proper area.

JOB SHEET

SMALL ENGINE REPAIR

NAME____ **DATE**_______________

UNIT: Principles of Carburetion

TOPIC: Test and Service a Fuel Pump

ESSENTIAL LEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(C), (ddd)(2)(D)

SPECIFIC BJECTIVE(S): After completing this lesson, the student(s) will be able to test and service the fuel pump correctly.

TOOLS AND EQUIPMENT:

- Open end wrenches
- Shop towels
- Hand tool assortment
- Container to catch fuel
- Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to test and service the fuel pump properly.

PROCEDURES AND/OR TASKS: **Note:** *Use proper safety precautions.*

1. Disconnect and ground spark plug wire.
2. Disconnect fuel line at carburetor (use back up wrench to prevent tube damage).
3. Hold small container under the fuel line to catch fuel.
4. Crank engine.
5. Fuel should flow out strongly and in regular squirts.
   Note: *If fuel flow is weak or erratic, check the fuel lines and fuel filter. If they are clear, the fuel pump should be replaced.*
6. If pump is bad, remove and replace.

7. Have instructor check work.
8. Clean work area and replace tools in proper area.

JOB SHEET
SMALL ENGINE REPAIR

NAME________________________________ DATE______________

UNIT:	Principles of Carburetion
TOPIC:	Service Sediment Bowl Fuel Strainer
ESSENTIAL ELEMENT(S):	(a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(E), (ddd)(2)(A), (ddd)(2) (C), (ddd)(2)(D)
SPECIFIC OBJECTIVE(S):	After completing this lesson, the student(s) will be able to service the sediment bowl fuel strainer correctly.

TOOLS AND EQUIPMENT:

Hand tool assortment
Cleaning solvent
Pan for cleaning parts
Shop towels
New gasket for glass bowl
Safety glasses
Pliers

GENERAL INSTRUCTIONS: Follow procedures to service the sediment bowl fuel strainer properly.

PROCEDURES AND/OR TASKS: **Note:** *Use proper safety precautions.*

1. Disconnect and ground spark plug wire.
2. Close fuel shut-off valve.
3. Loosen the jam nut and swing the wire bail to one side.
4. Remove the bowl with a twisting motion.
5. Remove the gasket.
6. Remove the strainer (filter) screen.
7. Wash the screen or filter element.

8. Clean and dry sediment bowl.
9. Open fuel valve and drain approximately one cup of fuel into a container, then shut off valve.
10. Install gasket, strainer, and sediment bowl.
11. Before tightening the jam nut, fill the sediment bowl by slowly opening the shut-off valve and then closing it.
12. Tighten bowl against the gasket with jam nut.
13. Check for leaks before operating the engine.
14. Replace spark plug wire to spark plug.
15. Start and operate engine for a few minutes and recheck for leaks.
16. Have instructor check work.
17. Clean work area and replace tools in proper area.

INFORMATION SHEET
SMALL ENGINE REPAIR

UNIT: Lubrication Systems

TOPIC: Purpose of Lubrication Systems

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(2)(A), (ddd)(2)(D)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to inspect and service the lubrication system properly.

SPECIFIC OBJECTIVE(S): After completing this information sheet, student(s) will be able to explain the purpose and components of the lubrication system, and service it with correct oils and lubricants.

BASIC ACADEMIC SKILLS APPLICATIONS: *Basic academic skills used with lubrication systems include mathematical principles, science, oral and written communications, and reading concepts and skills.*

Lubrication

Lubricating oil performs a number of important jobs with engines.

Oil lubricates and reduces the wear of moving parts by preventing metal to metal contact. A film of oil separates moving parts and reduces friction, allowing the parts to turn freely.

Oil helps cool the engine and absorbs heat while circulating around and through the various parts. The heat transferred to the oil reservoir of the crankcase is cooler than the oil returning from the engine parts.

The oil cleans the engine as it circulates. Oil washes and picks up impurities from internal combustion debris. The impurities are removed through a filter, or when the oil is drained.

Oil provides a seal between the piston rings and the cylinder walls.

Oil Selection

Oil is the most common fluid used for lubrication, and it is refined from crude petroleum, sometimes called mineral oil or petroleum oil. Some oils are made from non-petroleum sources and are known as synthetic oils. Oil used for small engines should have the correct **viscosity** and **service** rating for that engine.

The **viscosity** describes the thickness of the fluid. The common term for viscosity is body. An oil with a high viscosity would be a thick lubricant, such as standard transmission oil and rear axle oil.

A **low viscosity** oil is one with light body that flows freely. Engine oil must have a viscosity which will allow it to flow freely under cold conditions, but still have enough body to provide coating during times of high temperatures.

The standards for oil viscosity are set by the Society of Automotive Engineers (SAE). Thin oils, such as SAE 20, receive a low viscosity number, while thicker oils receive a higher number, such as SAE 40 or SAE 50. This viscosity number is stamped on top of each oil can. Check the operator's manual for the proper viscosity to use.

Some engines use a different viscosity oil during the summer than in the winter. Therefore, oil companies provide a multiple-viscosity oil, such as SAE 10-40. This type of oil will flow freely like a SAE 10 during cold weather, and will protect like SAE 40 when it is hot. The multiple-viscosity oil is made for engines operating in different climates. The viscosity rating with a W behind it means that the oil has been tested at 0^{O} F and rated for cold temperature operation, such as SAE 10w-30.

The American Petroleum Institute (API) sets the service rating to measure how well oil will hold up under severe wear and tear. Oil that does not do well receives a low rating; If it does well, it receives a high rating. The categories are SA (lowest) SB, SC, SD and SE (highest). These service ratings are printed on the side of the oil can.

The engine operator's manual will specify the service rating that should be used. A higher rating can be used, but **never** use a lower one.

Note: *No additives in oil.*

Lubrication Systems

Premix lubrication

The **premix lubrication** is used by most two-stroke engines. Both oil and gas are mixed and go in the fuel tank. A special two-stroke-cycle oil is used because it mixes well with gasoline and stays mixed for a long time. Some engines use 20 parts of gasoline for each part of oil, while other engines use a 50 to 1 mix, that is, 50 parts of gasoline to one part of oil. There is always more gasoline than oil in the mixture.

The premix fuel enters the crankcase through the reed valve, and is converted to a mist form in the crankcase. Droplets of oil fall on the engine parts to lubricate them. The advantage of premix lubrication is that it has no moving parts. If the operator does not mix the oil and gasoline in the appropriate proportions, however, the engine will be damaged.

Splash Lubrication

The **splash lubrication** system features an oil dipper arm on the connecting rod cap. The dipper is designed to pick up oil from the crankcase at each revolution, and splash it on the various moving parts. The cylinder walls also receive oil from the splashing.

The oil control ring on the piston removes the excess oil, and returns it to the crankcase preventing oil burning problems. The connecting rod bearings and piston pin receive lubrication through oil passage holes.

Pressure Lubrication

Pressure lubrication uses a pump to force oil around all moving parts.

The **oil pump** is the most important part of the pressure lubrication system. Small engines use a barrel pump which is made in two parts. The larger part is the body, and the smaller part, called a plunger, fits inside the larger. As the plunger moves out of the body on the intake stroke, it creates a vacuum. When the plunger moves into the body, it is called compression stroke. The pump pulls oil in on the intake stroke, and then pushes oil over the engine parts on the compression stroke. The body of the pump has a large, off-center, drilled hole. This hole fits around the camshaft. When the engine is running, this offset hole causes the body to move up and down. As the body moves up and down, the oil is pulled in by the intake and then pushed out by the compression stroke onto the engine parts.

The **oil flow** begins with the intake stroke. Oil is pushed out of the pump on the compression stroke through an oil hole. The oil goes through a hole between the main bearing and the camshaft to lubricate the main bearings. Another hole in the crankshaft lets oil flow from the main bearings to the connecting rod bearings. When the engine is running, oil will leak out between the crankshaft and the connecting rod. This oil is thrown off the crankshaft onto the cylinder walls and other moving parts, lubricating the cylinder walls.

Dry Sump Lubrication

This system is used to force oil through the engine parts and return the oil by pump to the oil tank. The oil flows from the tank by gravity to the high pressure pump, and then is forced to the engine parts for lubrication. The oil runs down the engine to a **sump**, where the oil is collected. A scavenger pump pulls the oil out and returns it to the oil tank located above the engine. There is never very much oil in the sump. This is why it is called a **dry sump.** With this type of system, more oil for the engine is available in the tank than could be stored in the engine.

Terms and Definitions

API is the American Petroleum Institute.

Blow-by occurs when gases under pressure leak past the piston rings during combustion and the power stroke.

Dipper is a device fastened to the connecting rod as a means of splashing oil.

Dry sump lubrication uses a scavenger pump to move oil from a sump under the engine to an oil tank above it.

Friction is a resistance to motion between two parts that causes wear and heat.

Lubrication reduces friction in an engine by providing oil between the moving parts.

Multi-grade oils are compounded to be light in cold temperatures and heavy in warm temperatures.

Oil is a fluid used for lubrication.

Oil galley is the passageway in the engine used to carry oil from one area to another.

Oil filter removes the abrasive debris from the oil.

Oil pan is the cover on the bottom of the engine block that provides a reservoir for the engine oil.

Oil pickup allows the oil pump to pick up oil that is free from sediment in the oil pan.

Premix lubrication is an oil and gasoline mixture used for lubrication and fuel.

Pressure lubrication is a system that uses a pump to force oil into engine parts.

Pressure relief valve is designed to limit maximum oil pressure in the lubrication system.

SAE is the Society of Automotive Engineers.

Service classification is the rating system for engine oil based on the type of service used.

Slinger is a device rotated by the camshaft for splashing oil.

Sludge is the heavy, thick residue found in the bottom of an oil pan caused by oil deterioration or contamination.

Splash lubrication is system whereby oil is splashed on engine parts for lubrication.

Viscosity is a measure of the fluidity of an oil at a given temperature.

"W" oils are suitable for winter service.

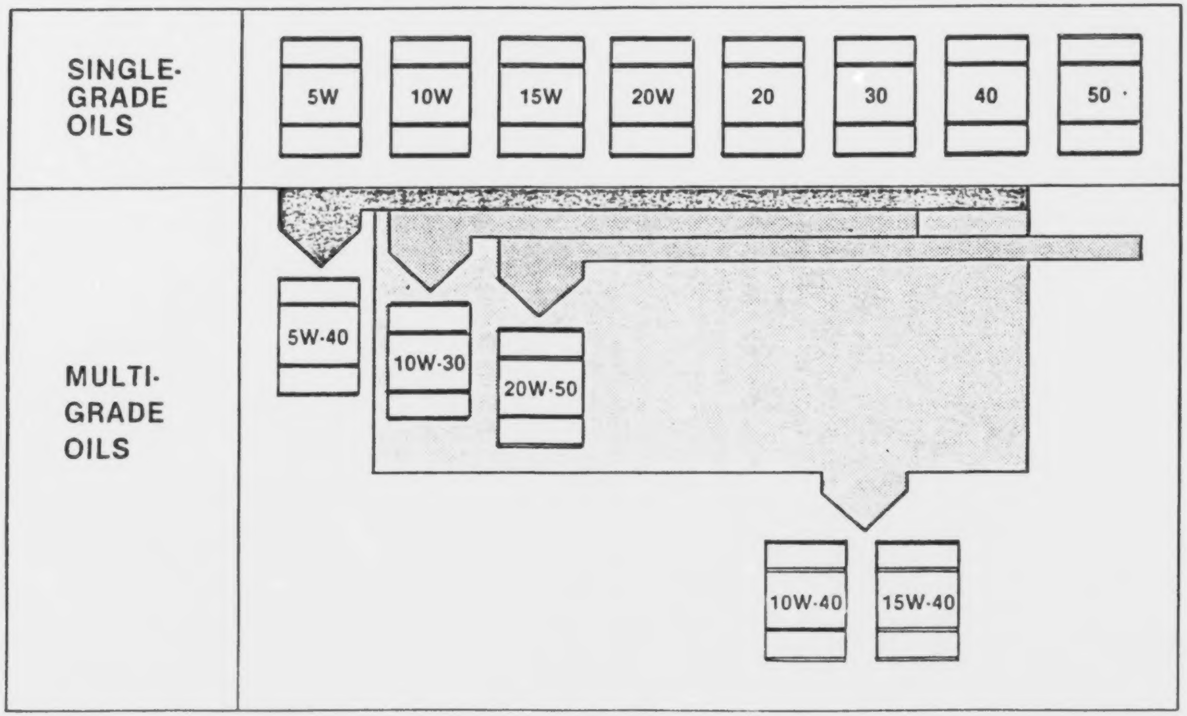
Pour point is the lowest temperature at which an oil will still remain a liquid.

Flash point is the temperature at which oil will begin to burn.

Sulfated ash content measures the percentage of residue weight left after the oil burns away.

Comparison of Crankcase Oils

(Viscosity-Grades)



SINGLE-GRADE OILS

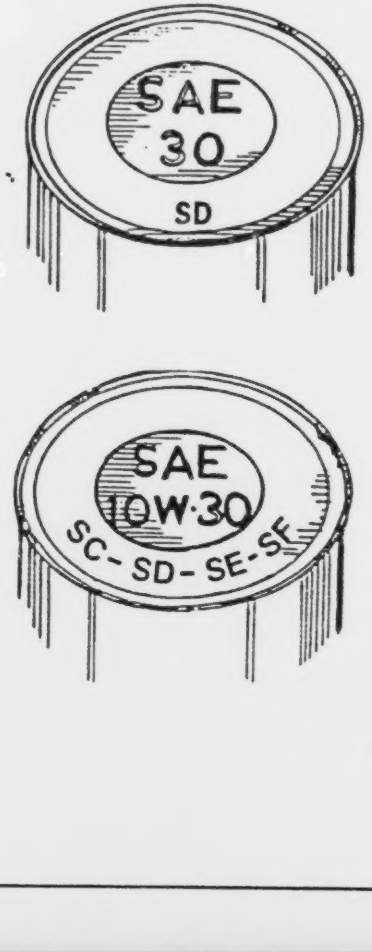
5W
10W
15W
20W
20
30
40
50

MULTI-GRADE OILS

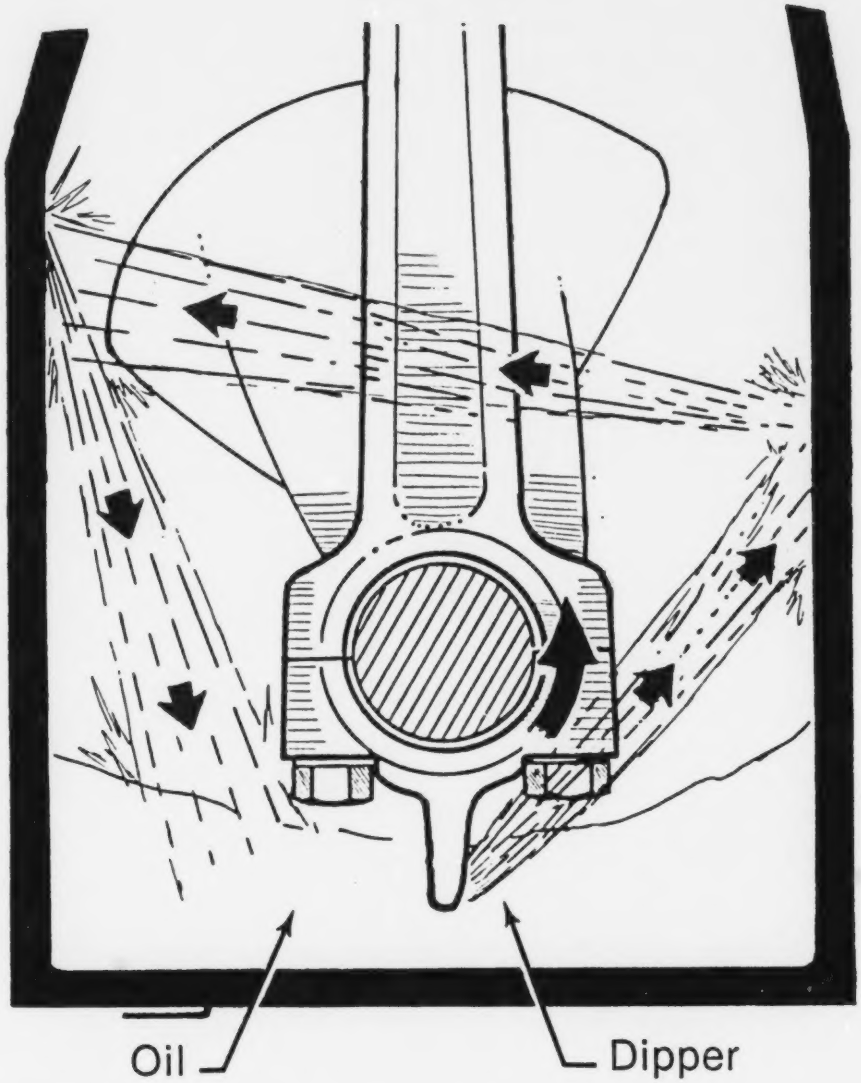
5W-40
10W-30
20W-50
10W-40
15W-40

API Classification System

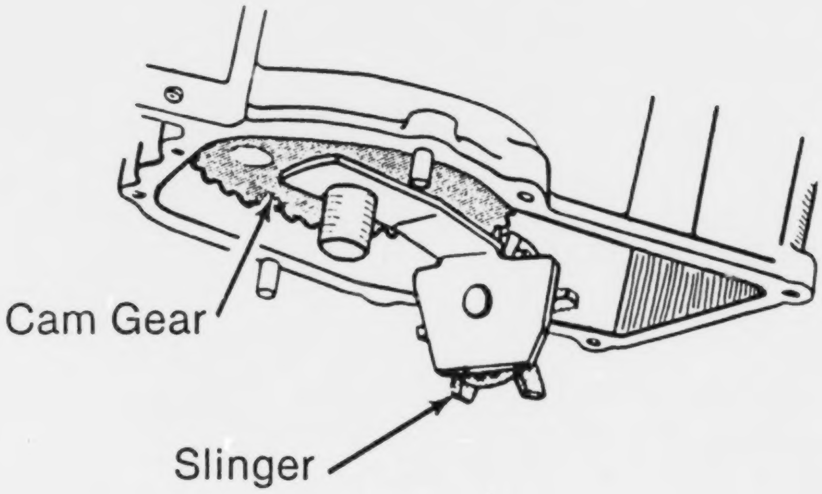
(NOTE: Check operator's manual for recommended oil classification. Use a high quality detergent oil classified "For Service SC, SD, SE, or SF." Classification markings are on the oil can.)

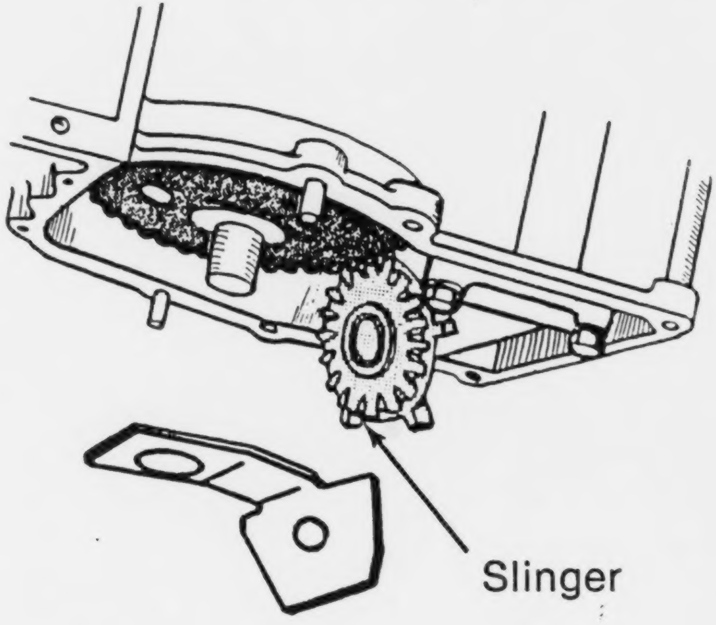

SAE
30
SD
SAE
10W·30
SC-SD-SE-SF

Dipper Lubrication System

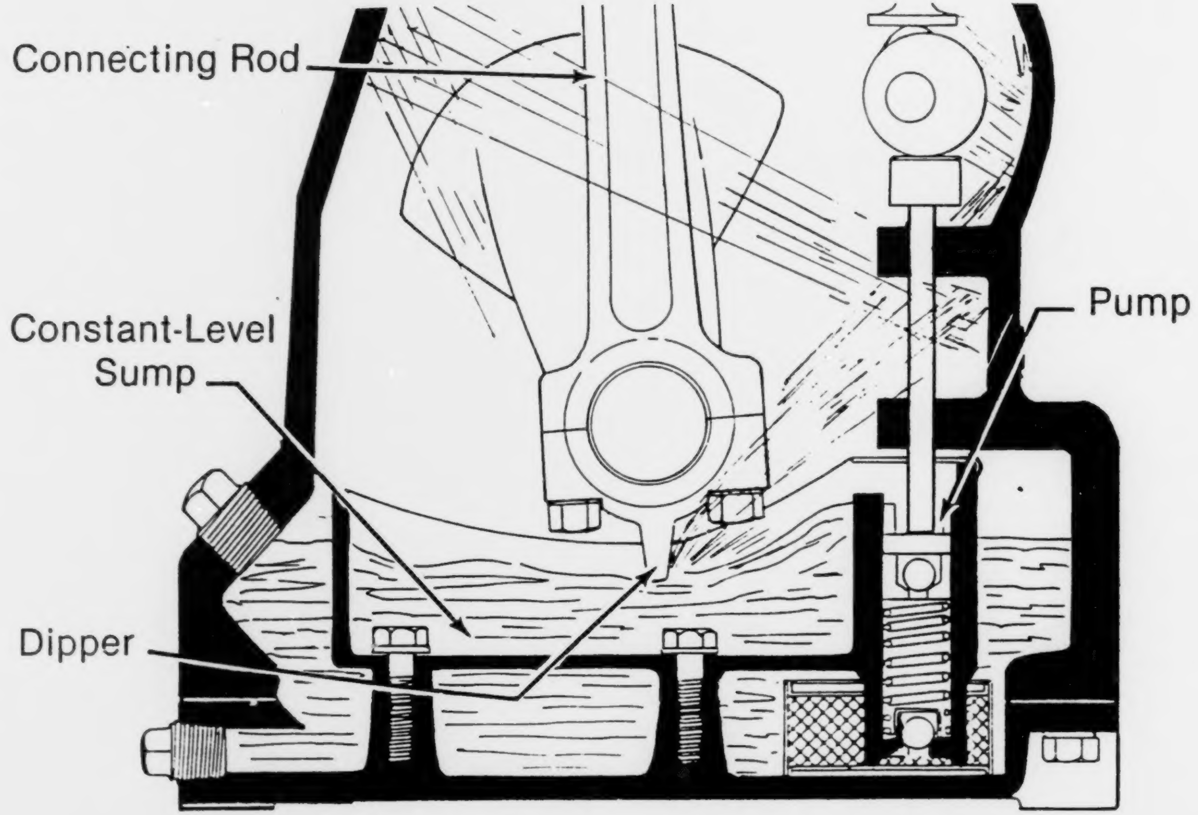


Slinger Lubrication System

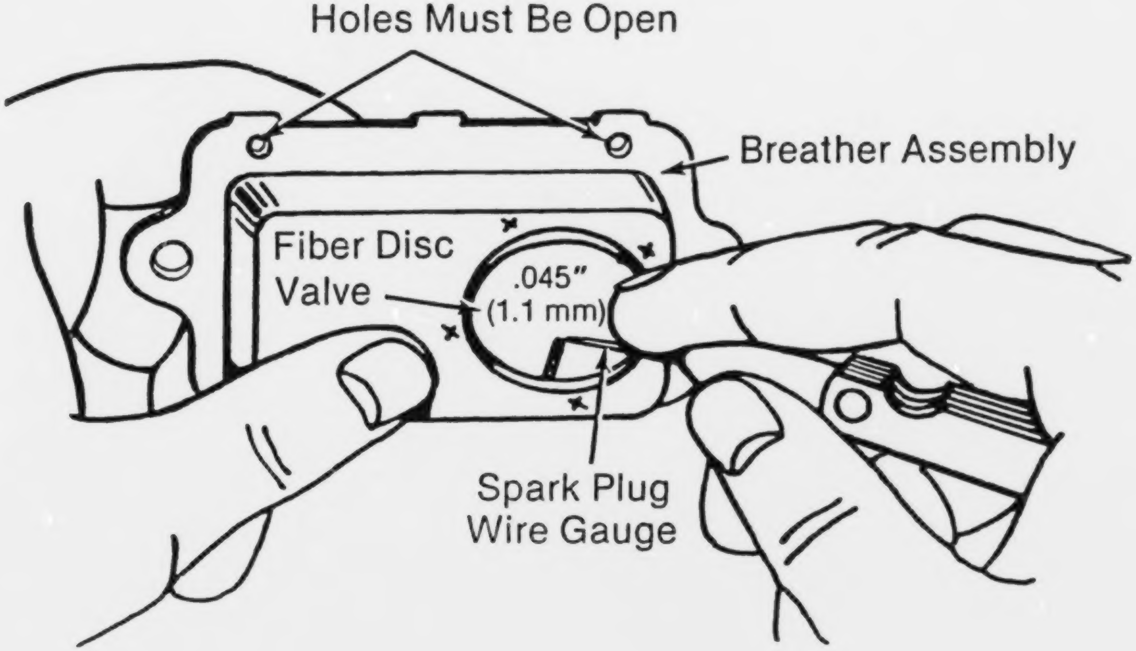

Cam Gear
Slinger



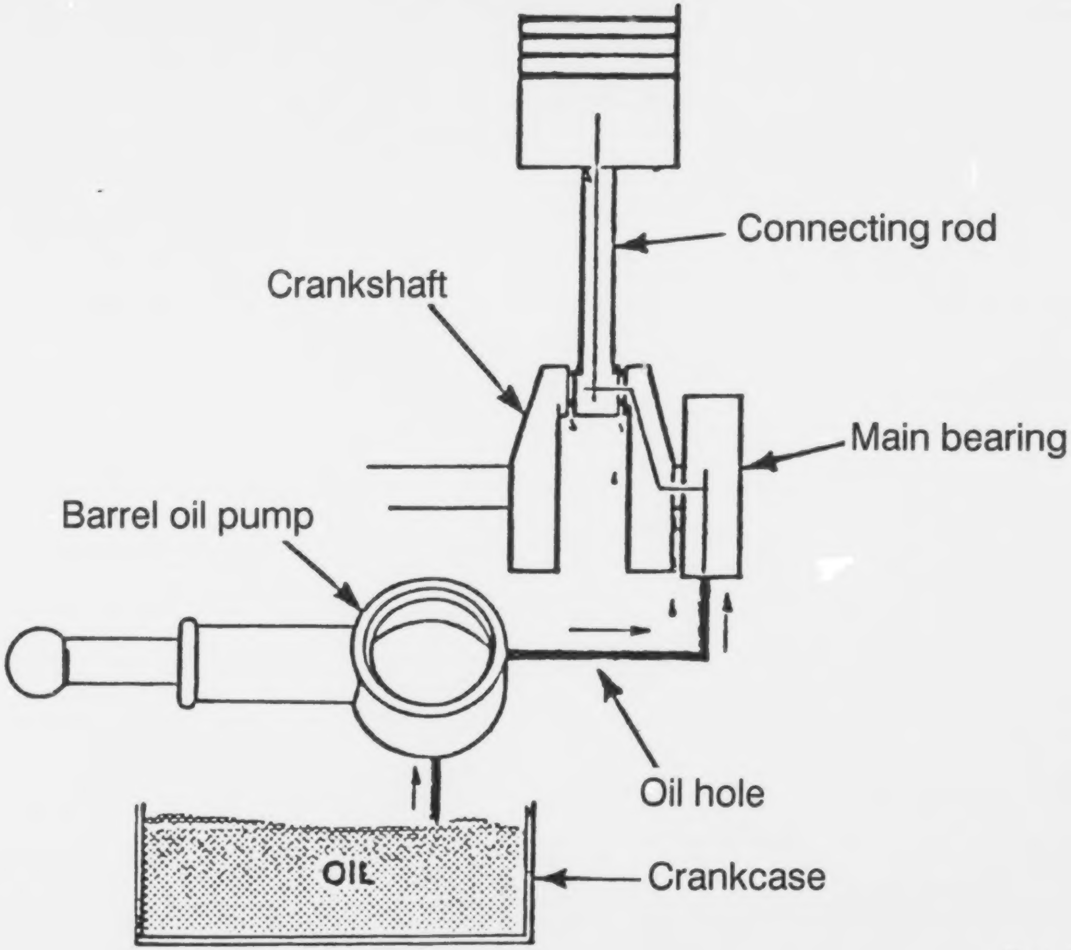
Dipper, Pump, and Constant Level Sump


Connecting Rod
Pump
Constant-Level Sump
Dipper

Crankcase Breather


Holes Must Be Open
Breather Assembly
Fiber Disc Valve
.045"
(1.1 mm)
Spark Plug Wire Gauge

Barrel Pump Oil System

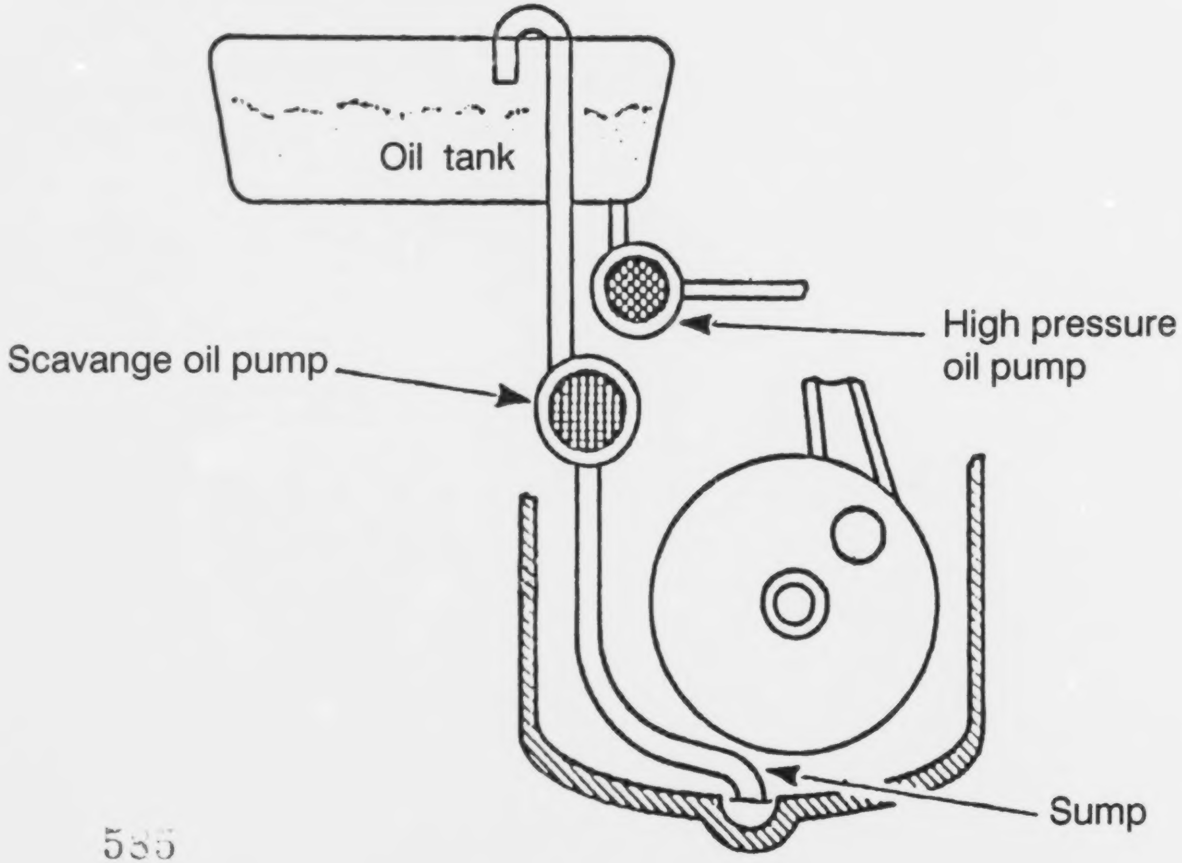

Connecting rod
Crankshaft
Main bearing
Barrel oil pump
Oil hole
OIL
Crankcase

TM-7

583

584

Dry Sump Lubricating System


Oil tank
High pressure oil pump
Scavange oil pump
Sump

ASSIGNMENT SHEET

SMALL ENGINE REPAIR

NAME____**DATE**____________________

UNIT Lubrication Systems

TOPIC: Purpose of Lubrication Systems

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms associated with lubrication systems by placing the correct number to the left of each definition.

______a. Oils compounded to behave as light oils at cold temperatures and heavy oils at warm temperatures

______b. Society of Automotive Engineers

______c. American Petroleum Institute

______d. A measure of the fluidity of an oil at a given temperature

______e. A device rotated by the camshaft for splashing oil

______f. Cover on the bottom of the engine block that provides a reservoir for the engine oil

______g. Device used to remove abrasive debris from the oil

______h. Device fastened to a connecting rod as a means of splashing oil

1. SAE
2. Viscosity
3. API
4. Multi-grade oil
5. Oil pan
6. Oil filter
7. Slinger
8. Dipper
9. "W" oils
10. Friction

_____i. Types of oils that are suitable for winter service

_____j. Resistance to movement between two objects placed in contact with each other

2. Indicate with a "√" which of the two lubrication systems is the splash system type?

_____a. Barrel and plunger type, gear and rotor type

_____b. Dipper type, slinger type

3. Complete the functions of engine oil by correctly filing in the blanks.

a. Reduces ____________________ and wear
b. ____________________ moving parts
c. Helps seal ____________________
d. Keeps parts ____________________

4. How are most two-stroke-cycle engines lubricated?

5. Where is the service rating of an oil found?

6. Complete the following statements concerning SAE viscosity.

a. Oils vary in viscosity as ____________________ changes.
b. Lighter oils for winter use are tested at __________ degrees F and carry a 5W, 10W, or 20W symbol.
c. The thicker type oil receives a ______________, such as SAE 40 or SAE 50.
d. "Body" is a common term used for ____________________.

7. How does premix (oil and fuel) enter the engine?

8. What is pressure lubrication?

9. When are "W" oils used most frequently?

10. Explain how oil cools the engine.

JOB SHEET
SMALL ENGINE REPAIR

NAME____DATE______________________

UNIT: Lubrication Systems

TOPIC: Change Engine Oil

ESSENTIAL ELEMENT(S) (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(2)(A), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to change the engine oil correctly.

TOOLS AND EQUIPMENT:

- Oil
- Drain pan
- Wrench to fit drain plug
- Oil can spout
- Shop towels
- Safety glasses
- Operator's manual

GENERAL INSTRUCTIONS: Follow procedures to change the engine oil properly.

PROCEDURES AND/OR TASKS: Check engine operator's manual for oil selection.
Note: *Always use safety precautions.*

1. Start engine, run to operating temperature, and shut off engine.
2. Disconnect spark plug wire and ground.
3. Place drain pan under drain plug.
4. Remove drain plug.
5. Observe color and condition of oil.
   Note: *Water or other contaminants may indicate problems.*

6. Allow time for oil to drain.
7. When oil stops completely, replace drain plug. (Start with fingers, then tighten with wrench)
8. Refill crankcase to recommended level with proper engine oil.
   Note: *Be sure filler spout is clean.*
9. Clean and replace oil filler cap.
10. Replace spark plug wire and connect ground.
11. Start engine and idle until hot.
12. Check for oil leaks.
13. Shut off engine.
14. Check oil level. Add oil if needed, but do not overfill.
15. Have instructor check work.
16. Clean work area and replace tools in proper area.

JOB SHEET

SMALL ENGINE REPAIR

NAME________________________ DATE________________

UNIT: Lubrication Systems

TOPIC: Service Crankcase Breather

ESSENTIAL ELEMENT(S) (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(2)(A), (ddd)(2)(D)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to service the crankcase breather correctly.

TOOLS AND EQUIPMENT:

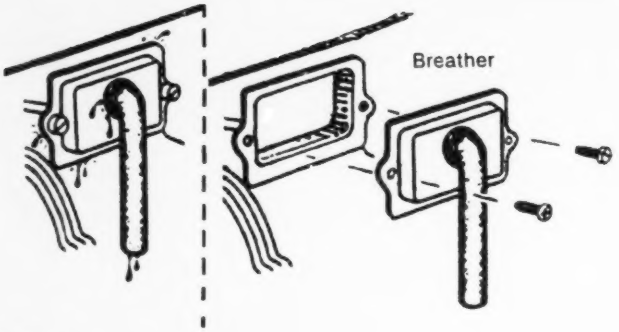
Hand tool assortment
Clean towels
Solvent
Container for cleaning parts
New gasket
Feeler gauge
Safety glasses

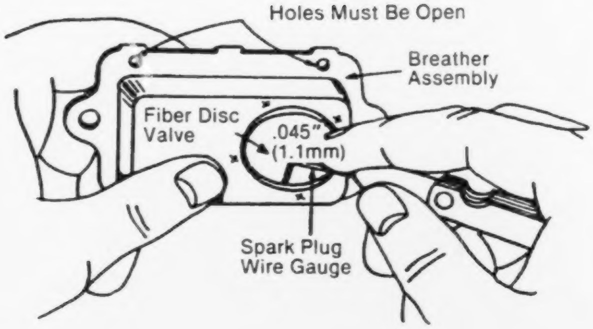
GENERAL INSTRUCTIONS: Follow procedures to service the crankcase breather properly.

PROCEDURES AND/OR TASKS: Check manufacturer's manual for specifications.
Note: *Use safety precautions.*

1. Disconnect spark plug wire and ground.
2. Check breather for proper operation.

3. Remove crankcase breather.




Holes Must Be Open
Breather Assembly
Fiber Disc Valve
.045"
(1.1mm)
Spark Plug Wire Gauge

4. Check breather for proper clearance. If a .045 wire gauge will enter the space between fiber disc valve and body, a new breather should be installed.

5. Inspect venting elbows for loose fit and damaged tubes; replace if necessary.

6. Clean parts in solvent.

7. Dry breather with compressed air.

8. Install breather using a new gasket.

9. Replace spark plug wire and ground.

10. Run engine for a few minutes.

11. Check breather for oil leaks.

12. Stop engine.

13. Have instructor check work.

14. Clean work area and return tools to their proper place.

STUDENT INFORMATION SHEET

SMALL ENGINE REPAIR

UNIT: Starter Systems

TOPIC: Starter Systems and Components

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(D)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to remove and replace a starter, and identify and discuss components of starter systems.

SPECIFIC OBJECTIVE(S): After completing this information sheet, the student(s) will be able to identify, remove, and service starters on small engines correctly.

BASIC ACADEMIC SKILLS APPLICATIONS: *Basic academic skills used with starters include mathematical principles, oral and written communications, and science.*

Starter Functions

The starter provides a means for turning the crankshaft until the combustion cycle starts. Once the cycle starts, it continues to repeat itself, causing the engine to run.

The starter turns the crankshaft fast enough for a combustible fuel air mixture to be drawn into the combustion chamber to be compressed and ignited. When this takes place, the starter is released and the engine will run on its own.

The starter must have a source of either manual or electric power. A drive mechanism engages the crankshaft during cranking and disengages after the engine starts. A drive mechanism also transmits power, much like a rope and pulley, to a gear drive or V-belt and pulley.

Types of Starters

There are two basic types of starters: the **manual** and **electric**.

Small engines are started by turning the flywheel with a manual starter.

The three most common types of manual starters are: **rope-wind**, **rope-rewind** or **recoil**, and **windup or impulse**.

The **rope-wind** starter consists of a T-handle secured on one end and a knot tied on the other end of the rope. First, the rope is wound around the flange on the flywheel, and then the engine is turned by a strong pull on the rope.

The **rope-rewind** or **recoil** starter is a little more automatic. Each time the rope is pulled, the rope is automatically rewound by a recoil spring. This engages and releases the starter drive because the rope is permanently attached. Other concepts of rewind starters are vertical-pull, rope-rewind, and gear driven starters.

Electric Starters

Electric starters are becoming very popular on small engines, especially for 5 horse power and above. The electric starter almost eliminates manual starting. If maintained properly, the electric starter will save time on a job that requires frequent stopping and starting. Some electric starters are designed to operate on alternating current and some on direct current.

The **bendix type starter drive** is the most common type used on direct current starters. When the switch is turned on, the electric motor starts. The pinion gear will not turn because of inertia. This will cause it to move endwise on the threaded shaft until it engages the flywheel gear. When this motion stops and the pinion gear rotates with the shaft, the starter is engaged. The flywheel turns to start the engine.

When the engine starts, turn the switch off. The pinion gear rotates faster than the starter shaft because it is being driven by the flywheel. It will spin back on the threaded shaft away from the flywheel gear, causing it to disengage itself. The heavy spring on the starter shaft helps relieve the shock on starter parts as the starter cranks the engine.

The electric starter can be tested easily with a **D.C. voltmeter**. The voltmeter can be connected without disconnecting any of the circuit components.

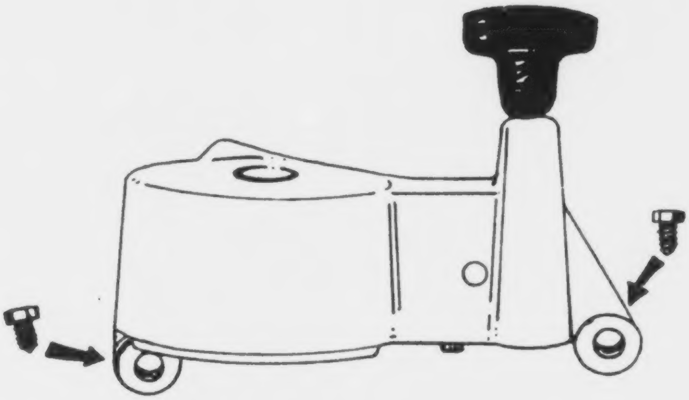
Starter-Generator

The 12-volt combination **direct current starter-generator** is the most commonly used electric starter on small engines. When the starter switch is closed, the electric circuit is completed between the starter-generator and the battery. The current will flow from the battery (negative to positive) through the ground wire to the starter-generator. The starter-generator acts like an electric motor turning the engine crankshaft through a belt drive.

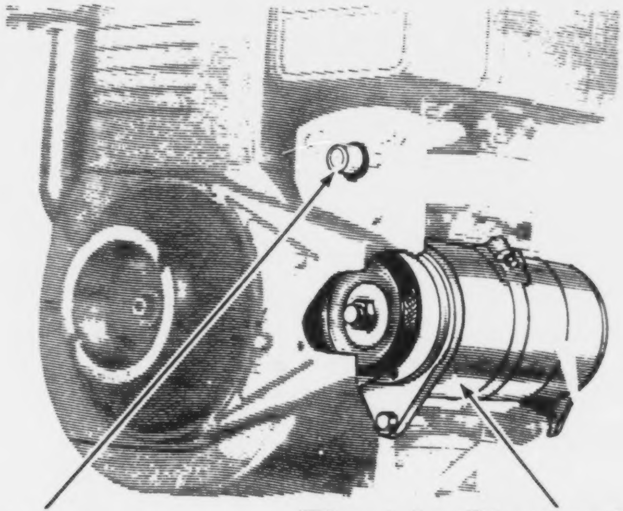
The starter switch is released when the engine starts. The starter-generator is never disengaged like other starters. The engine drives the starter-generator, thus acting as a generator to produce electric energy to recharge the battery. The amount of charge to the battery is controlled with a current voltage regulator.

The **voltage regulator** controls the current from the generator while the engine is operating. This protects the generator from excessive output and possible failure and also protects the battery from being overcharged. If the battery is overcharged, it will get hot, and the water in the electrolyte will boil away.

Types of Starters



Vertical Pull

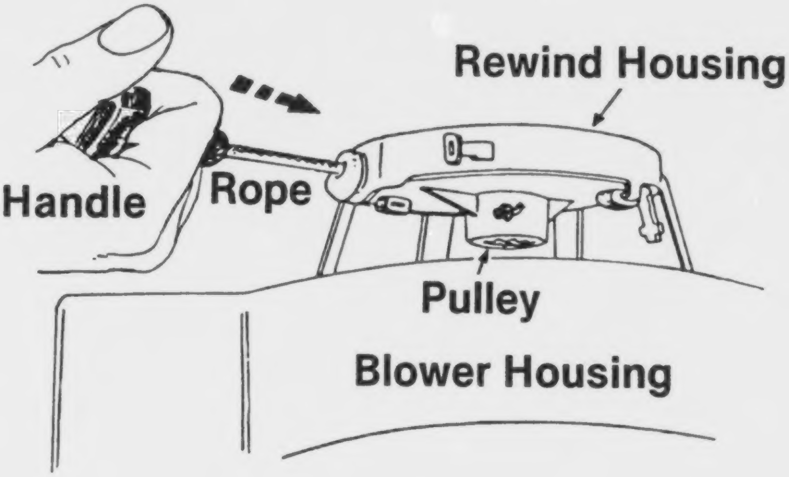


Starter Switch
Electric Starter-Generator

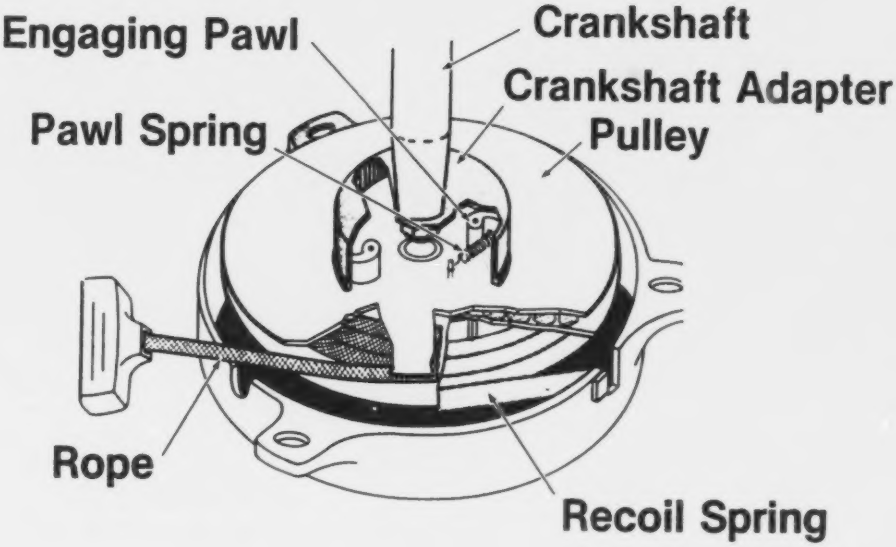
Electric

Types of Starters

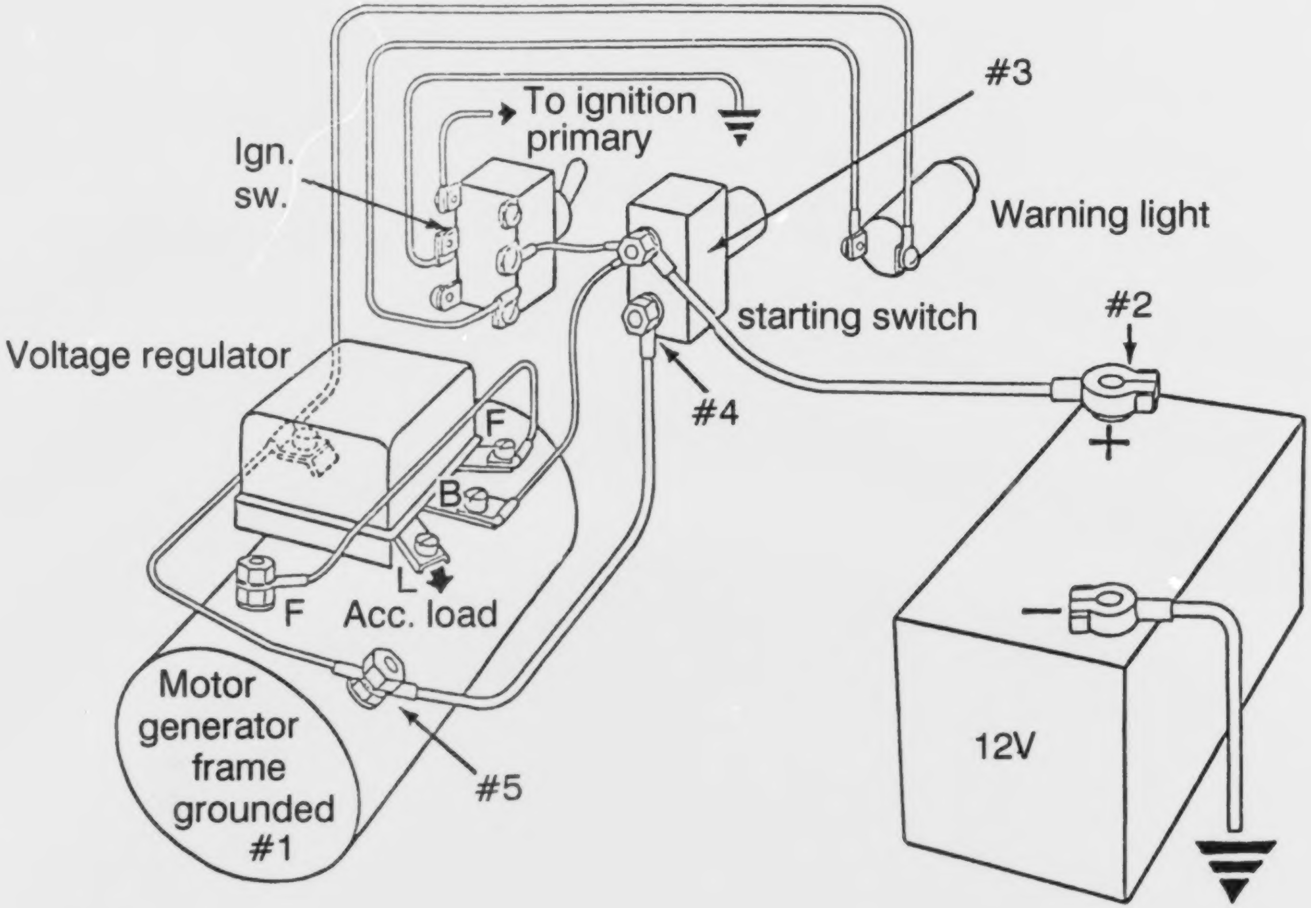
Rope Wind


Rewind Housing
Handle
Rope
Pulley
Blower Housing

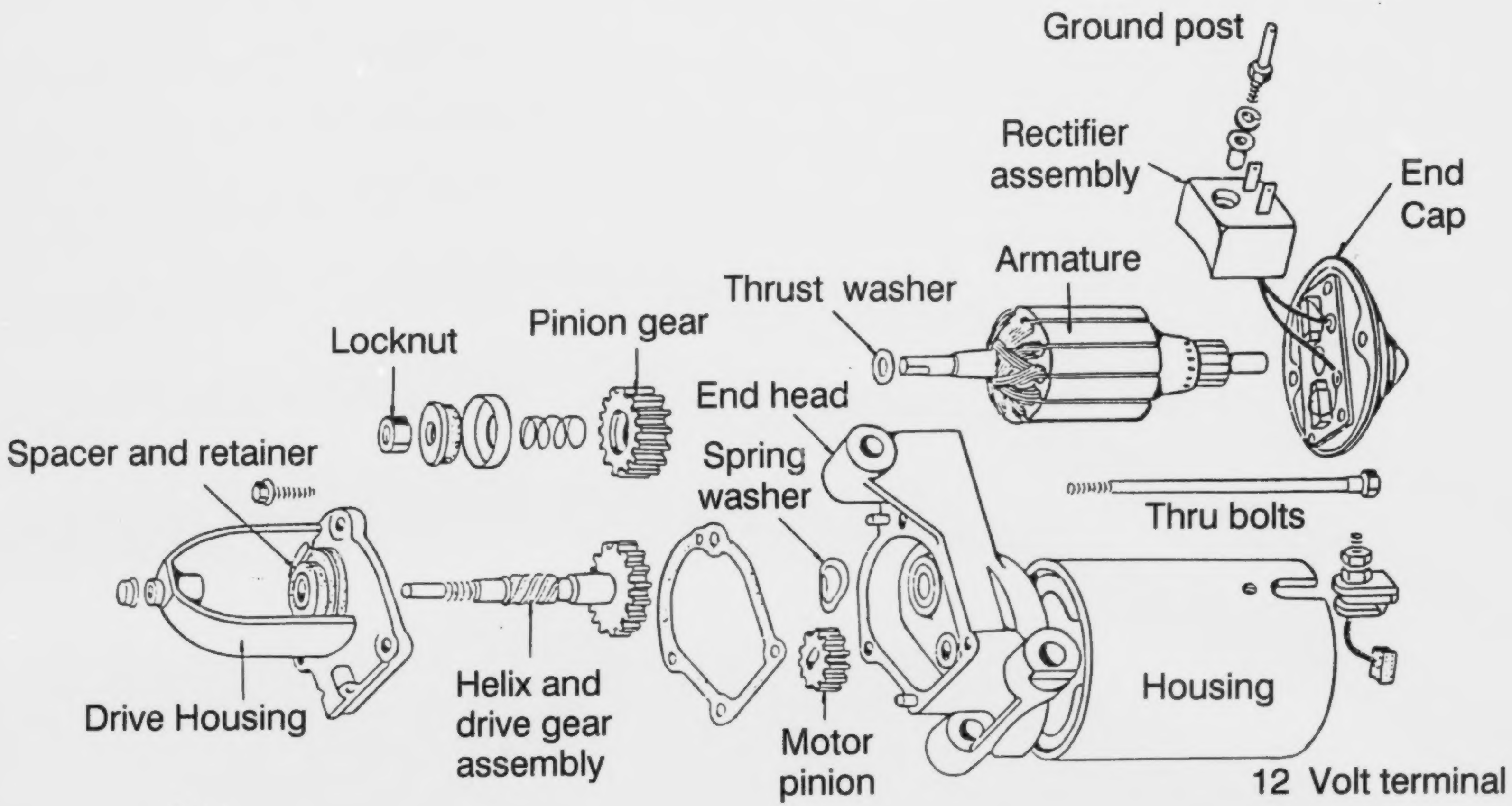
Rope Rewind


Engaging Pawl
Crankshaft
Crankshaft Adapter
Pawl Spring
Pulley
Rope
Recoil Spring

12 Volt Starter-Generator System


To ignition primary
Ign. sw.
#3
Warning light
starting switch
#2
Voltage regulator
#4
+
F
B
L
F
Acc. load
−
Motor generator frame grounded #1
#5
12V

Geardrive Starter Motor


Ground post
Rectifier assembly
End Cap
Armature
Thrust washer
Pinion gear
Locknut
End head
Spring washer
Spacer and retainer
Thru bolts
Drive Housing
Helix and drive gear assembly
Motor pinion
Housing
12 Volt terminal

601

602

BEST COPY AVAILABLE

ASSIGNMENT SHEET
SMALL ENGINE REPAIR

NAME______________________________ **DATE**____________________

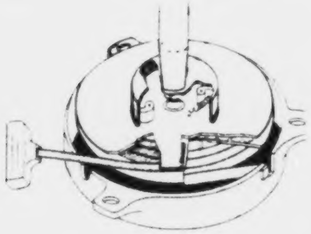
UNIT: Starter Systems

TOPIC: Starter Systems and Components

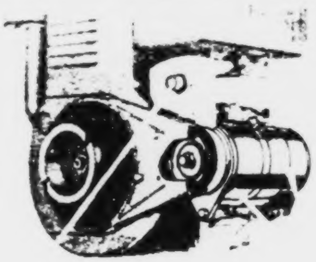
DIRECTIONS: Read and answer the following questions in the space provided.

1. Identify the types of small gas engine starters.

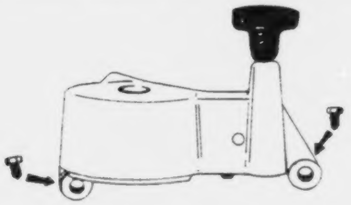
a.________________________



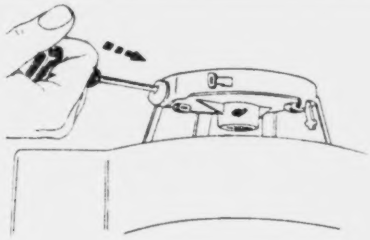
b.________________________



c.________________________



d.________________________



2. Explain the purpose of a starter.

3. The two basic type starters are:

603

4. Name three of the most common starters.

5. Explain why the rope-rewind starter is more automatic than the rope-wind starter.

6. The most common type electric starter drive is ____________________.

7. The electric starter can be tested with a ____________ voltmeter.

8. In what way will current flow from the battery to the starter generator?

9. The ____________________ controls the amount of charge to the battery.

10. Explain what would happen if the battery is overcharged and gets too hot.

JOB SHEET

SMALL ENGINE REPAIR

NAME____________________________________DATE____________________

UNIT:	Starter Systems
TOPIC:	Disassemble, Test, Reassemble, and Replace a D.C. Starter
ESSENTIAL ELEMENT(S):	(a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)
SPECIFIC OBJECTIVE(S):	After completing this lesson, the student(s) will be able to remove, service, and replace a D.C. starter correctly.
TOOLS AND EQUIPMENT:	Hand tool assortment Armature grounder and test light Solvent and parts brush or rag Ignition wrench set Awl Safety glasses
GENERAL INSTRUCTIONS:	Follow procedures to service a D.C. starter properly.
PROCEDURES AND/OR TASKS:	Check manufacturer's manual for specifications. **Note**: *Follow safety procedures.*

Remove starter

a. Disconnect battery ground cable.

b. Remove cables and electrical wires from starter.

CAUTION: Use two wrenches on terminals when removing top nut to prevent twisting terminal.

Note: *Carefully identify location of wires with masking tape.*

c. Remove starter mounting bolts as required.

d. Remove starter brackets and shields as required.

e. Remove starter from engine.

Disassemble starter

a. Clean outside case with solvent and brush or rag.

Note: *Do not use excessive amounts or submerge starter in solvent. Solvent should not be allowed to enter the starter.*

b. Scribe mating surfaces for reassembling.

c. Remove thru bolts.

d. Remove end cap.

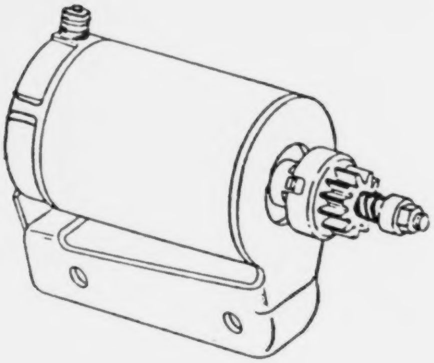
e. Lift spring and release brush from end cap.

f. Remove front plate with armature.

Note: *Some models may have starter mounting attached to front plate.*

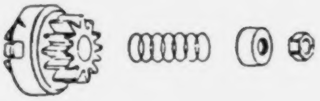
g. Place armature in vise.

Note: *Be sure to use wooden blocks or jaw protectors on the vise to keep from damaging armature.*



h. Disassemble drive assembly.

1) Remove stop nut.



2) Separate spring, washers, and drive pinion.

Note: *Be sure to note location of thrust washers on armature shaft if used.*

606

Test and service

a. Clean all starter components.

Note: *Clean all parts by wiping with clean cloths. The armature, field coils, and starter drive assembly must not be washed in solvent.*

b. Arrange all starter components for inspection.

c. Inspect starter bushings for looseness and replace as required.

d. Inspect starter brushes for wear.

Note: *Brushes worn to half their original length or less should be replaced.*

e. Inspect the starter drive.

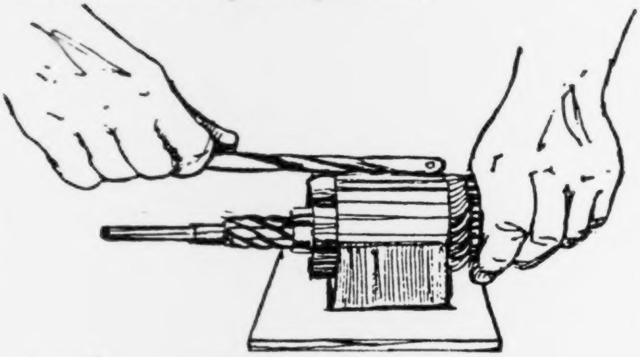
Note: *The starter drive pinion gear should turn freely in one direction and lock when turned slowly in the other direction.*

f. Inspect armature commutator.

Note: *If the armature commutator is rough or out-of-round, it should be turned down using suitable equipment.*

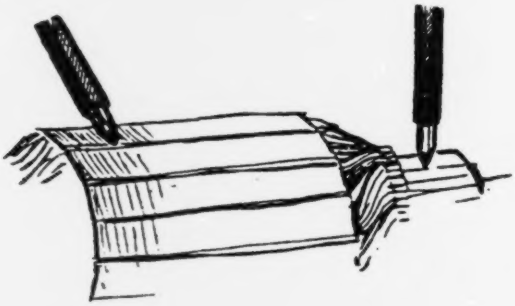
g. Test the armature for short circuits.

Note: *Place the armature on a growler and rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and will require replacement.*

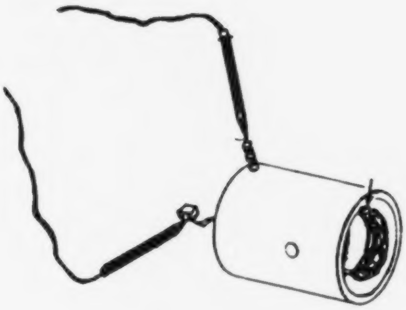


h. Check armature for ground.

Note: *Place one lead of a test lamp on the armature core or shaft and the other on the commutator. If the lamp lights, the armature is grounded and will require replacement.*



i. Check field coil for open circuit.



Note: *Place one lead of the test lamp on the insulated brush and the other on the field connection tab. If the lamp does not light, the field coil is open and will require replacement.*

j. Replace worn or damaged parts.

Reassemble starter

a. Place front plate back on armature.

Note: *Be sure and replace thrust washers if used.*

b. Replace drive assembly.

Note: *Torque stop nut to manufacturer's specifications.*

c. Lift spring and reinstall brush in end cap.

d. Place end cap on starter.

e. Line up scribe marks.

f. Install thru bolts.

Note: *Torque to manufacturer's specifications.*

Replace starter

a. Clean starter mounting surfaces.

b. Position starter in mounting position and start bolts.

c. Tighten mounting bolts securely.

d. Place all wire and cables on correct terminals.

e. Tighten nuts securely.

Note: *Double wrench as in removal, hold terminals securely, and do not overtighten top nuts.*

f. Replace all brackets and shields.

g. Tighten all bolts and nuts securely.
h. Replace battery ground cable.
i. Start engine several times to check starter.
j. Have instructor check work.
k. Clean work area and put away tools.

JOB SHEET

SMALL ENGINE REPAIR

NAME____________________________________ **DATE**______________________

UNIT: Starter Systems

TOPIC: Replace Starter Rewind Spring

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the students(s) will be able to remove, service, and replace a starter rewind spring correctly.

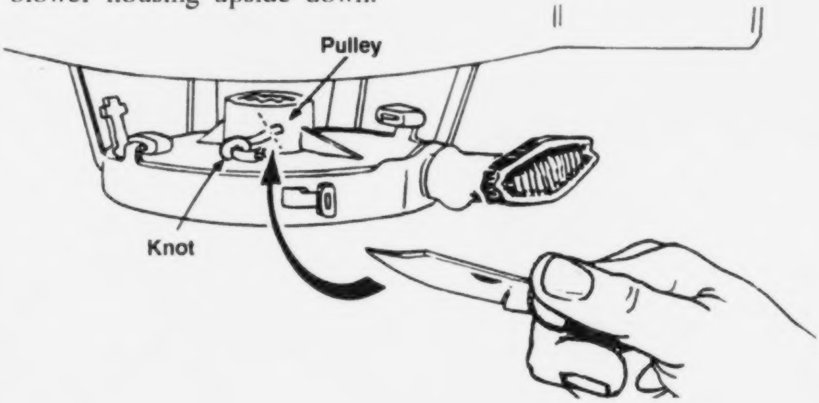
TOOLS AND EQUIPMENT:

Hand tool assortment
Rope inserter
¾-in. square piece of square stock
New recoil spring
New starter rope
Small amount of grease
Cleaning solvent
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to service the starter rewind spring properly.

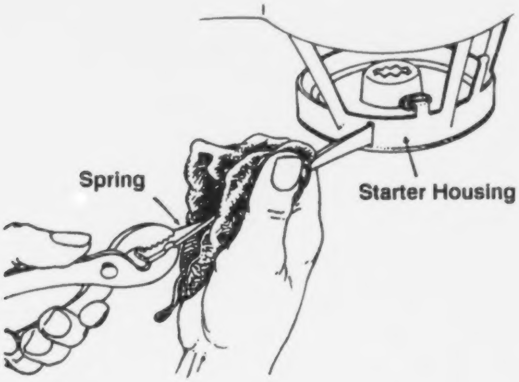
PROCEDURES AND/OR TASKS: **Note:** *Wear proper safety equipment.*

1. Remove shroud or blower housing from engine.
2. Turn blower housing upside down.

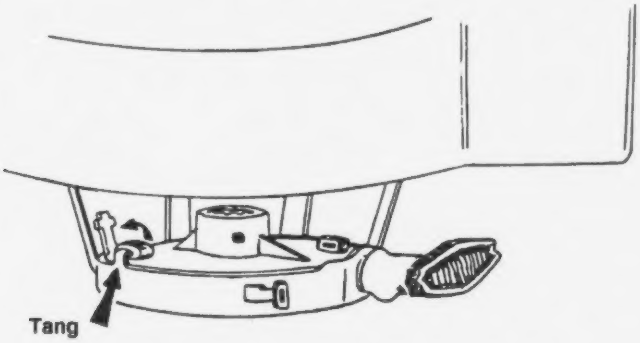


3. Cut knot at starter pulley and remove rope.

4. Grasp outer end of starter spring with pliers and pull spring out of housing as far as possible.
   Note: *Clean the spring with shop towel as you remove it.*



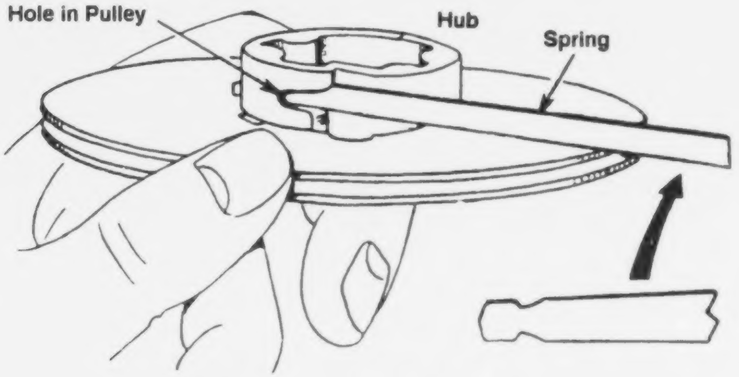
5. Bend one of the tangs up and lift out starter pulley turning spring ¼. turn to disconnect.
   CAUTION: Do not allow spring to fly out of housing because injury could result.



6. Clean starter housing pulley and spring in solvent and wipe dry.

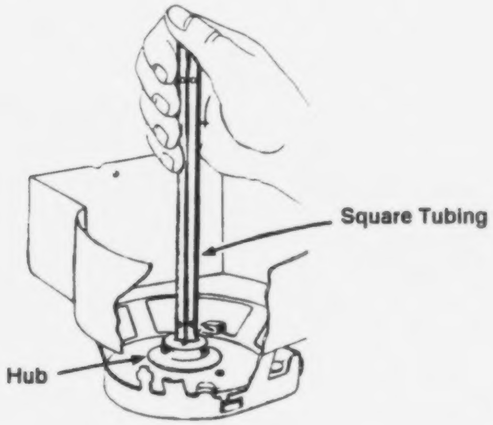
7. Straighten spring to allow easier installation and restore tension.
   Note: *Replace spring if it is damaged; replace nylon bumpers if worn.*

8. Insert other end of spring through slot in blower housing, and hook the end of spring into pulley hub.


Hole in Pulley
Hub
Spring

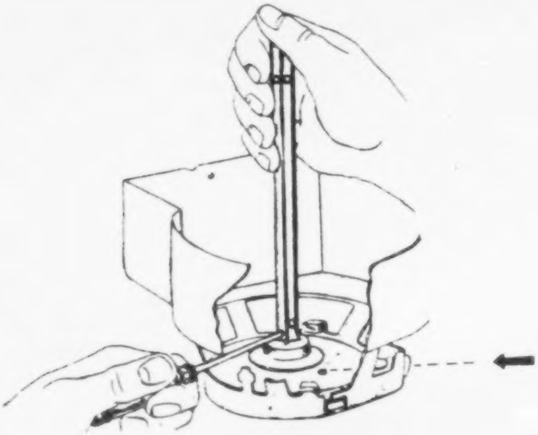
9. Place small amount of grease on pulley, set pulley into housing, and bend tang down. **Note:** *Make sure pulley is depressed fully into blower housing when measuring tang gap.*

10. Place ¾-in. square tubing into center of pulley hub.


Square Tubing
Hub

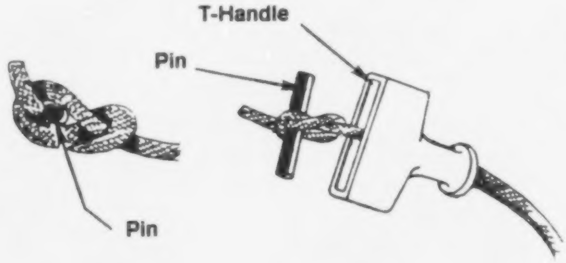
11. Wind pulley counterclockwise until spring is tight.

12. Hold square tubing securely and back off the pulley one turn or until hole in pulley for rope and eyelet in blower housing are in alignment.

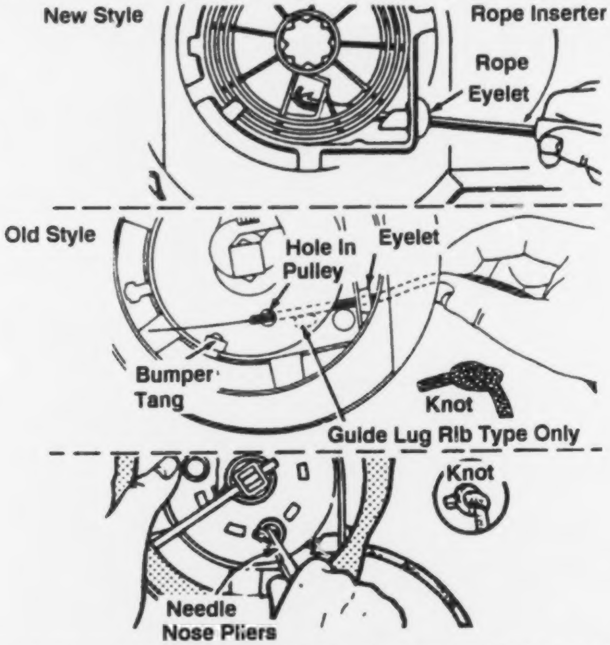


13. Replace starter rope with a new rope if it is frayed.
Note: *Four feet of rope is needed for most starters and each end of new rope should be burned with a match and wiped with a rag to prevent swelling and unraveling.*

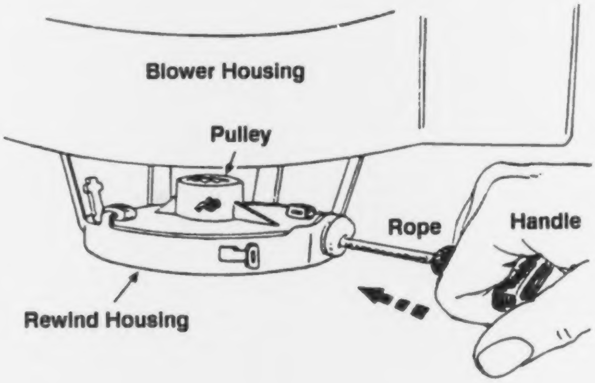
14. Insert rope through T-handle and loosely tie a figure 8 knot; place the pin through the knot and pull it tightly into handle.



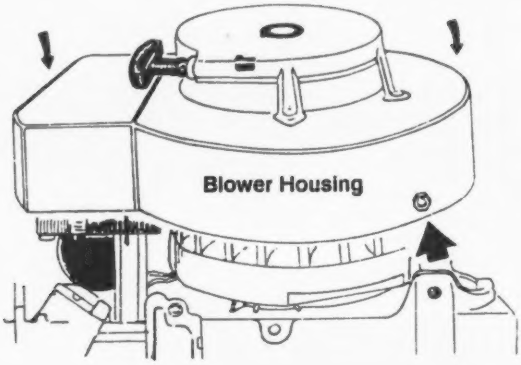
15. Use a rope inserter tool to thread rope through rope eyelet in housing and out pulley hole; tie a knot in rope and pull it tightly into knot cavity.


New Style
Rope Inserter
Rope
Eyelet
Old Style
Hole In Pulley
Eyelet
Bumper Tang
Knot
Guide Lug Rib Type Only
Knot
Needle Nose Pliers

16. Remove square tubing to release spring tension and allow rope to rewind onto pulley slowly.


Blower Housing
Pulley
Rope
Handle
Rewind Housing

17. Install blower housing on engine.



18. Reconnect spark plug wire.

19. Start engine several times to be sure starter is operating correctly.

20. Have instructor check work.

21. Clean work area and put tools away.

JOB SHEET

SMALL ENGINE REPAIR

NAME____________________________________ **DATE**____________________

UNIT: Starter Systems

TOPIC: Service the Vertical Pull Starter

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to service and replace the vertical pull starter correctly.

TOOLS AND EQUIPMENT:

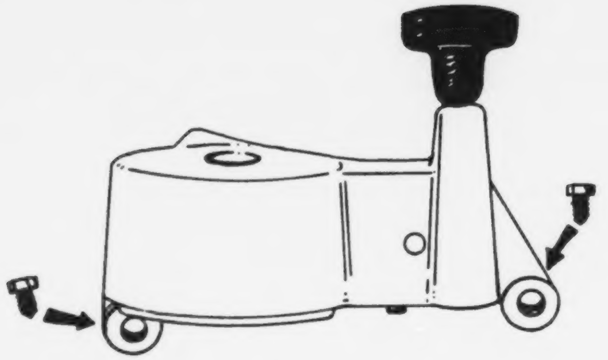
New spring
New starter rope
Cleaning solvent
Safety glasses
Assortment of hand tools
Rope inserter tool
Safety gloves

GENERAL INSTRUCTIONS: Follow procedures to service the vertical pull starter properly.

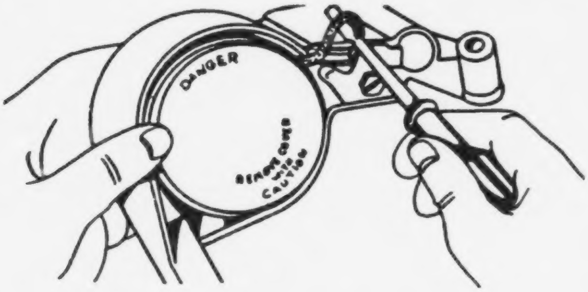
PROCEDURES AND/OR TASKS: **Note:** *Use proper safety precautions.*

1. Read operator's manual.
2. Wear proper safety equipment.
3. Organize your work station.
4. Disconnect spark plug wire.

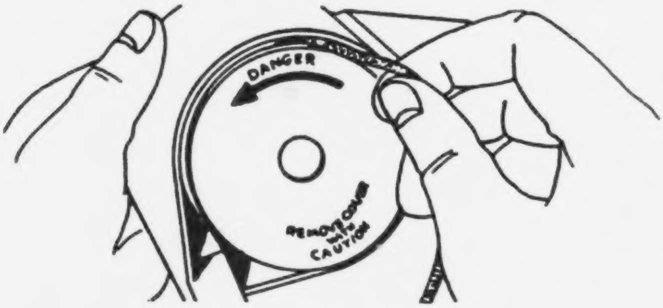
5. Remove starter from engine.



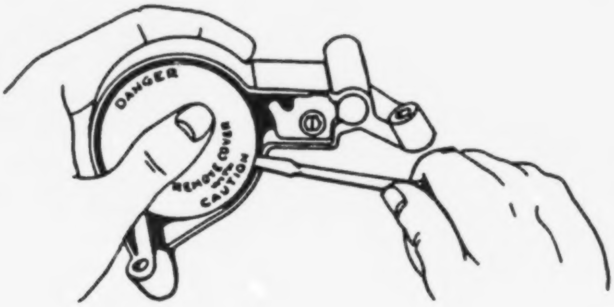
6. Remove tension from rope and use a screwdriver to lift the rope up 10- to 12-in.


DANGER
REMOVE COVER WITH CAUTION

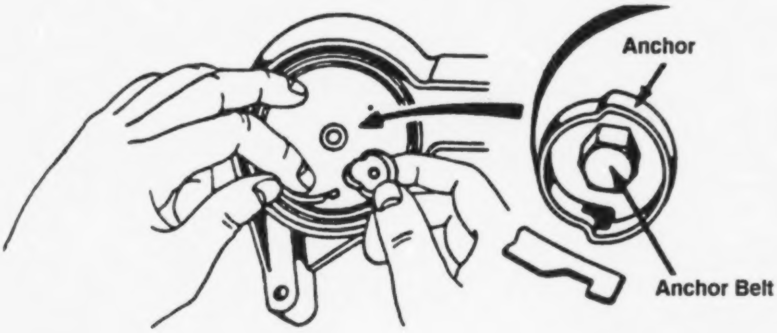
7. Wind the rope and pulley 2 to 3 turns counterclockwise to release spring tension. **CAUTION: Do not pull rope with pulley cover removed unless the spring is released.**


DANGER
REMOVE COVER WITH CAUTION

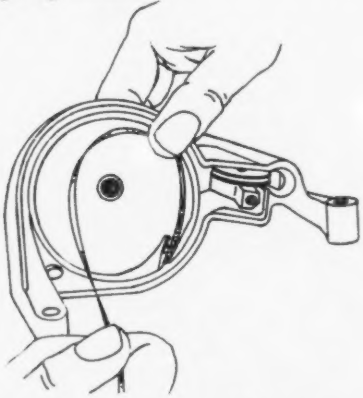
8. Remove cover with a screwdriver.
CAUTION: Read warning on plastic cover and wear safety glasses.


DANGER
REMOVE COVER WITH CAUTION

9. Remove anchor bolt and spring anchor to loosen pulley assembly from housing.

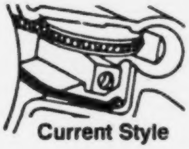

Anchor
Anchor Belt

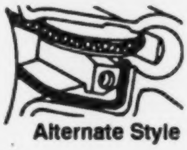
10. Unwind spring carefully, remove, and inspect for breakage.
Note: *If spring is not being removed, always replace pulley cover after removing the anchor bolt and spring anchor.*

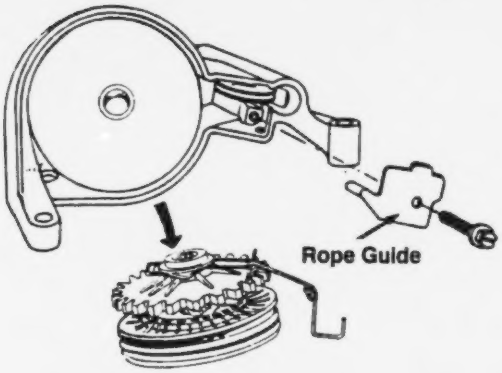


11. Remove rope guide.

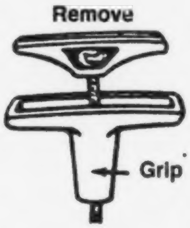
Note: *Before removing pulley from housing, note position of the link for reassembling. Remove pulley assembly from housing slowly.*

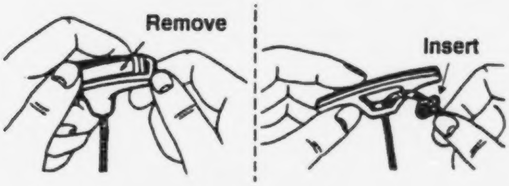

Current Style

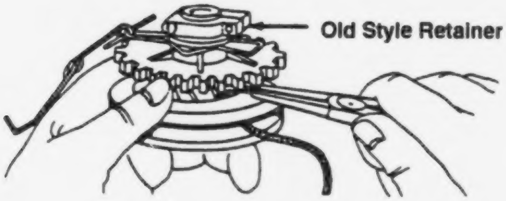

Alternate Style



12. Remove insert from handle and untie knot.


Remove
Grip


Remove
Insert

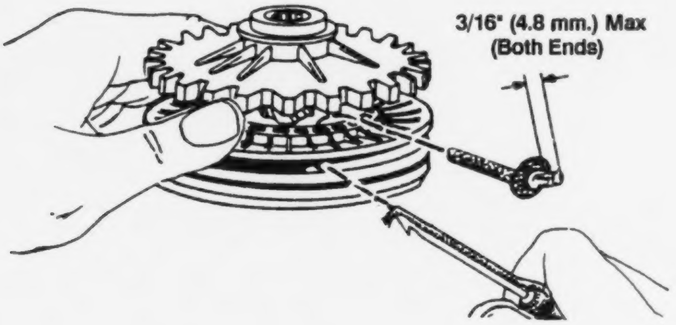

Old Style Retainer

BEST COPY AVAILABLE

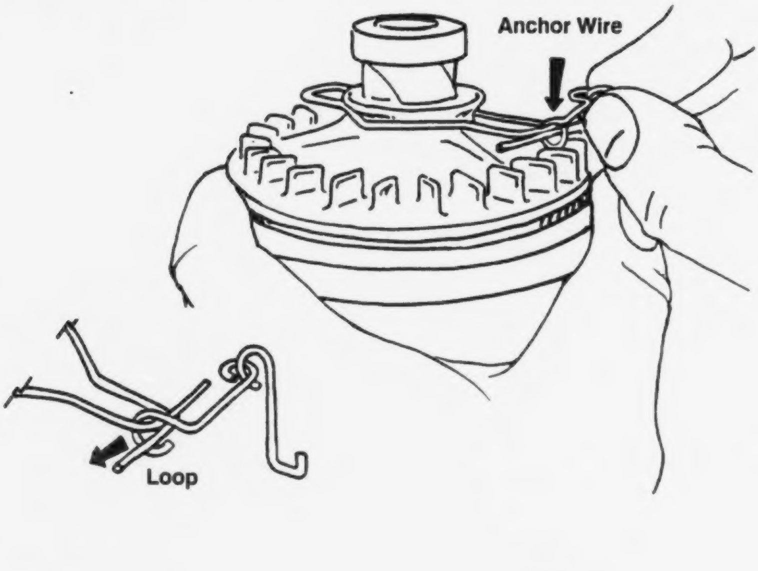
13. Unwind rope from pulley, grasp knotted end with needle nose pliers, and remove rope.

14. Clean all dirty or oily parts in solvent for reassembly.

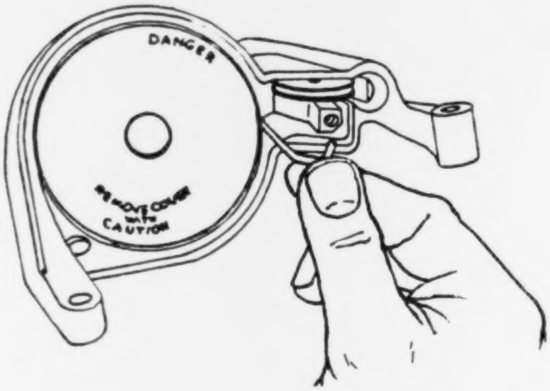
15. Insert new rope into the pulley using the rope inserter tool, and tie small knot, heat seal, and pull back into pulley.
    Note: *Make sure rope does not interfere with gear assembly. A total of 48-in. of #4 rope will be needed.*



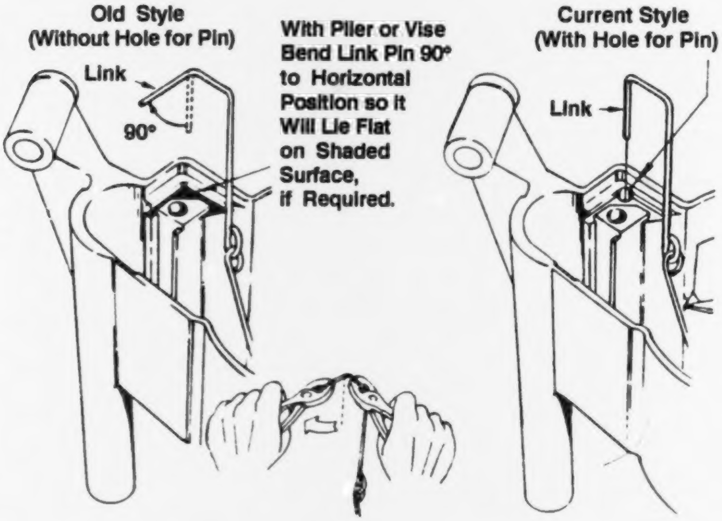
16. When installing the break spring, note the position of the loop on the anchor wire. The rounded portion should point toward the teeth of the gear.



17. Holding the link, install pulley assembly into housing.

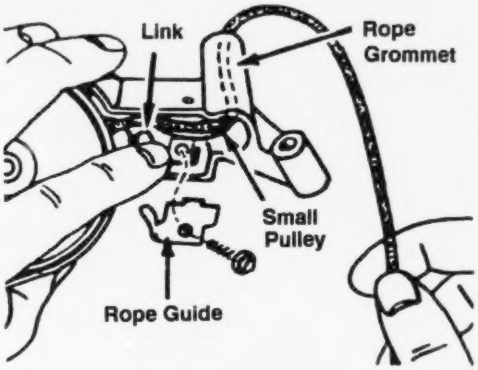

DANGER
REMOVE COVER WITH CAUTION

18. Using appropriate illustration, install link into housing.
Note: *Older link styles may be modified as illustrated.*

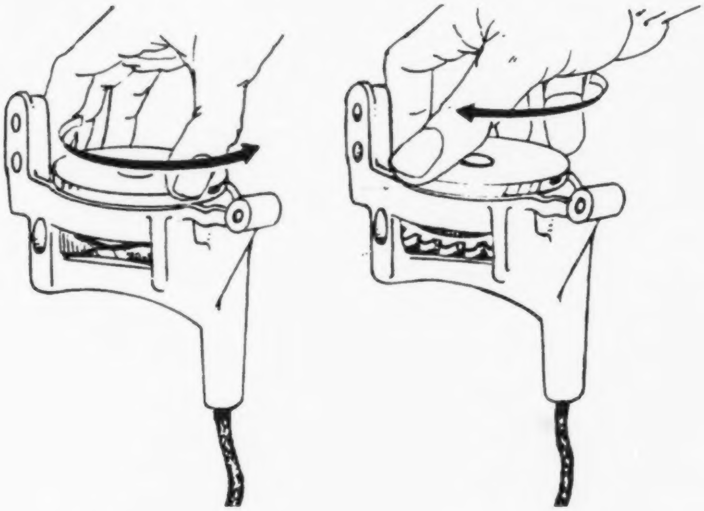

Old Style
(Without Hole for Pin)
Link
90°
With Plier or Vise Bend Link Pin 90° to Horizontal Position so it Will Lie Flat on Shaded Surface, if Required.
Current Style
(With Hole for Pin)
Link

621

19. Lead rope over small pulley, through rope grommet, and install rope guide.

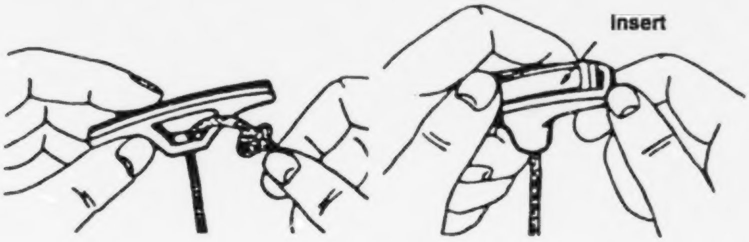

Link
Rope Grommet
Small Pulley
Rope Guide

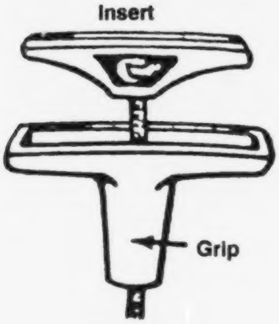
20. Check the link for proper friction by manually rotating pulley assembly.
    Note: *The gear should move to both extremes of its travel; if not, replace the link assembly.*



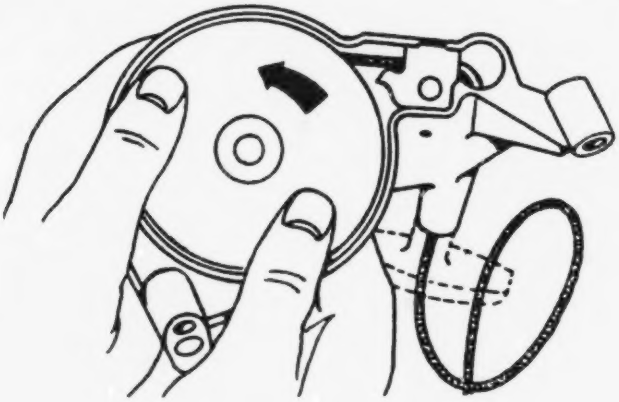
21. Thread rope through grip and into insert. Tie a small tight knot and heat seal to prevent loosening.

22. Pull knot into pocket and snap insert into grip.

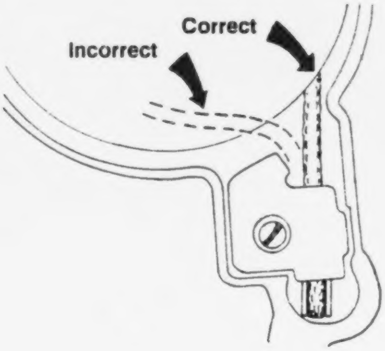




23. Wind pulley in a **counterclockwise** direction until rope is fully retrieved.

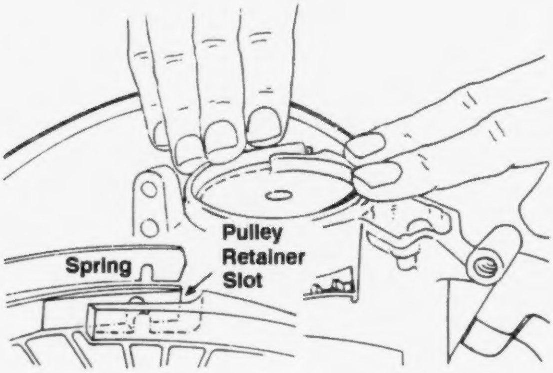


24. Check position of rope.
    Note: *It should not be touching the rope guide.*

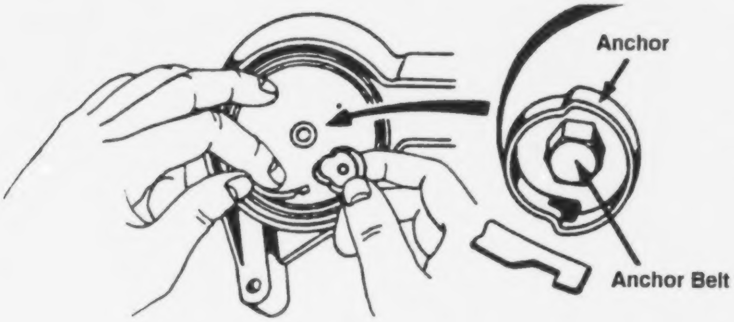

Correct
Incorrect

25. Secure starter in vice and oil the spring lightly.

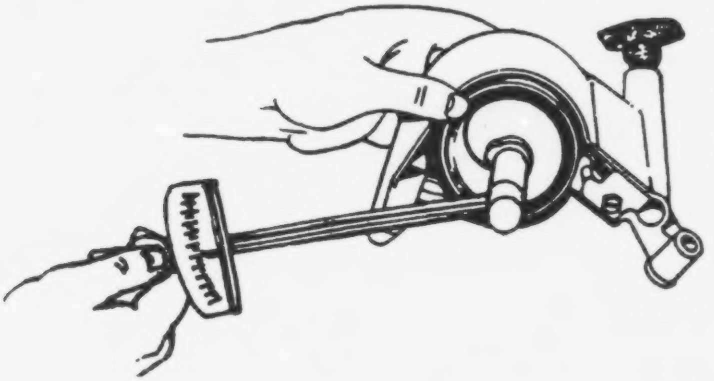
26. Install spring by hooking end in pulley retainer slot and wind spring into housing.


Pulley
Retainer
Slot
Spring

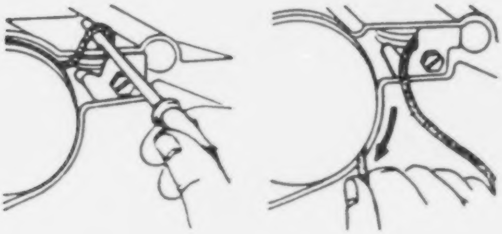
27. Hook end of spring to anchor and install bolt.


Anchor
Anchor Belt

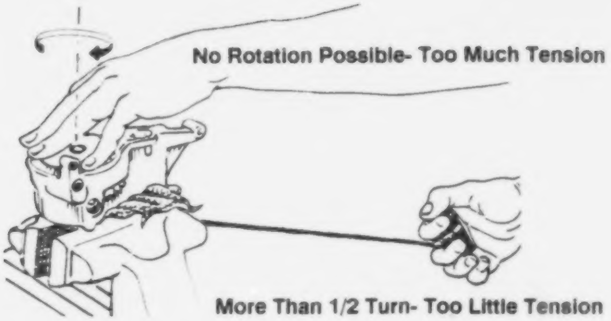
28. Torque to 75 to 90-in.-pounds and replace cover.



29. Wind rope in a **clockwise** direction two to three turns around pulley to secure proper spring tension.
Note: *To wind starter spring, pull approximately 1 foot of rope out of pulley.*



30. Check spring tension.

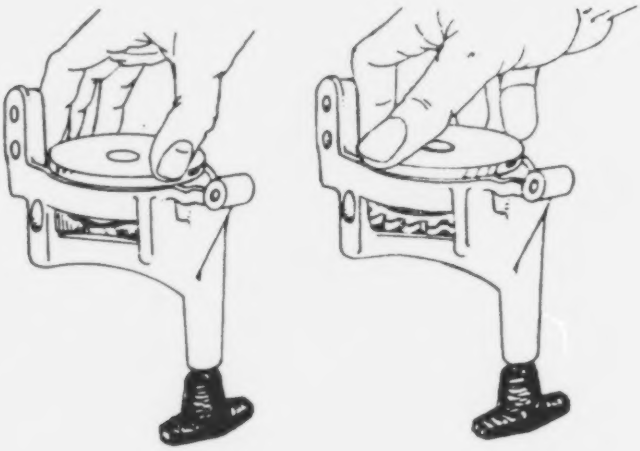

No Rotation Possible- Too Much Tension
More Than 1/2 Turn- Too Little Tension

a. When rope will not fully retract, wrap rope around pulley one more turn in a **clockwise** direction.

b. If there is too much spring tension, pull the rope out so that it is fully extended and hold lightly; rotate the pulley clockwise.

Note: *The pulley should rotate no more than ½ turn. If pulley cannot be rotated, the spring is wound too tight. Unwind the rope one turn at a time until proper spring tension is obtained.*

31. Check starter for proper operation.
Note: *The gear should move in and out.*



32. Install starter assembly on engine and check operation by pulling starter rope.
Note: *Pulley gear should engage the flywheel.*

33. Reconnect the spark plug wire.

34. Start engine several times to be sure starter is operating correctly.

35. Have instructor check work.

36. Clean your work area and put away tools.

STUDENT INFORMATION SHEET

SMALL ENGINE REPAIR

UNIT:	Measurement Instruments
TOPIC:	Measurement and Instruments
ESSENTIAL ELEMENT(S):	(a)(4), (a)(7)(A),(a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B), (ddd)(2)(C), (ddd)(2)(D), (ddd)(2)(E)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to use a micrometer, vernier caliper, dial indicator, telescoping gauge and other measuring instruments, and discuss the use of measuring instruments.
SPECIFIC OBJECTIVES(S):	After completing this information sheet, the student(s) will be able to measure and give correct dimensions of machined parts, and identify parts of measuring instruments correctly.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with measurement include mathematical principles, the application of reading concepts and skills, and oral and written communications.*

Using Measurement Instruments

There are two measurement systems used today: the U.S. system and the Metric system. The most common system may be divided into units of length measurement and units of weight or mass measurement. The length measurement is important because most specifications used by the small engine mechanic are measurements of length.

The length measurement units are as follows:

12-in. = 1 ft
3 ft = 1 yd
5½ yds = 1 rod

For weight measurement:

16 Drams = 1 oz
16 Ounces = 1 lb

Small engine specifications are often written in terms of a part of an inch. Fractions and decimals are used to subdivide an inch. A typical ruler is divided into these units, the smallest being 1⁄64 of an inch.

Measurement fractions:

1-in. (one inch)
1⁄2-in. (one half inch)
1⁄4-in. (one quarter inch)
1⁄8-in. (one eighth inch)
1⁄16-in. (one sixteenth inch)
1⁄32-in. (one thirty-second inch)
1⁄64-in. (one sixty-fourth inch)

When measurements smaller than 1⁄64 of an inch are necessary, use the decimal system of dividing an inch. The inch is divided by ten with this system, this in turn by ten, and so on.

Measurement by decimals:

1.0-in. (one inch)
0.1-in. (one tenth inch)
0.01-in. (one hundredth inch)
0.001-in. (one thousandth inch)
0.0001-in. (one ten thousandth inch)

Most small engine components must be measured within one thousandth of an inch. A mechanic sometimes has specifications to measure as close as one-ten-thousandth of an inch.

The Metric Measurement

The metric system is a simple measuring system to use. The small engine mechanic and the auto mechanic must be familiar with both the U.S. and metric systems.

The mechanic may have a specification written in millimeters, but have measuring tools that measure in thousandths of an inch. He or she must use a conversion chart to change from one system to the other. (A conversion chart is shown on TM 13.)

Using the Outside Micrometer

The basic parts of the outside micrometer are shown on TM-5.

The spindle is attached to the thimble on the inside. The part of the spindle concealed within the sleeve and thimble is threaded to fit a nut in the frame. The frame is held stationary while the thimble is revolved by the thumb and finger. The spindle revolves with the thimble, and moves through the nut in the frame approaching or receding from the anvil.

629

The article to be measured is placed between the anvil and the spindle. The measurement of the opening between the anvil and the spindle is shown by the lines and figures on the sleeve and the thimble.

One complete revolution of the spindle will move it longitudinally 1/40 or .025 of an inch. The sleeve is marked with 40 lines to the inch, and this corresponds to the number of threads on the spindle. When the micrometer is closed, the beveled edge of the thimble coincides with the line O on the sleeve, and the O line on the thimble agrees with the horizontal line on the sleeve.

Dial Indicator

The measurement is shown by a pointer on the face of the gauge. Dial indicators measure in either thousands of an inch (0.001-in.) or in hundredths of a millimeter (0.01 mm). The scale is divided into 100 divisions, each representing .001 of an inch. The indicator should be placed in a position so that the plunger is directly against the part. Always read the dial indicator straight on. Looking at it from the side can cause considerable error.

Telescoping Gauge

This gauge consists of a spring-loaded piston which telescopes within a cylinder. It is used with the outside micrometer to measure the inside dimension of a hole.

The gauge is placed in a hole, then the spring-loaded piston is allowed to expand to the size of the hole. Tighten the stem to hold the gauge at this point. The exact size of the hole is then found by measuring across the two contacts with an outside micrometer for the actual reading for the size of the hole.

Terms and Definitions

The **dial indicator** is a gauge used to measure movement, play, contour, or runout of a engine part.

Error is the mistake made in the reading or total measurement.

The **feeler gauge** measures the space between two surfaces.

The **graduation** is the marking found on rules and scales to denote the unit of length.

The **inside micrometer** measures the size of holes, such as small engine cylinders.

The **outside micrometer** measures the outside of an object, such as a crankshaft or piston.

Readable measure is the accurate or true measurement.

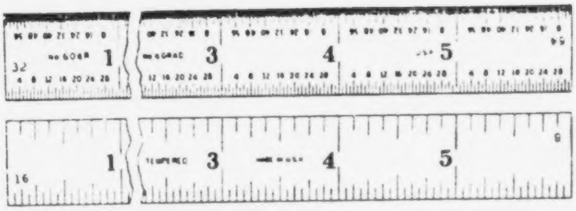
Reference point is the starting point of measurement for both workpiece and rule.

The **steel rule** is used for low precision measuring, and is graduated in fractional or decimal parts of an inch.

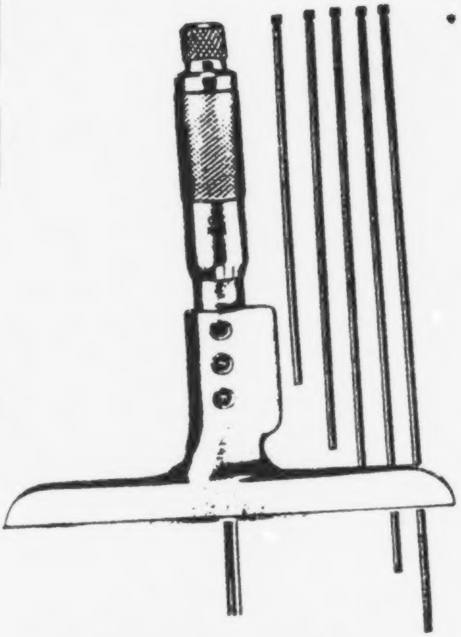
The **telescoping gauge** is a measuring tool with a spring-loaded piston that telescopes within a cylinder. It is used to measure the inside of a hole.

The **vernier caliper** makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter.

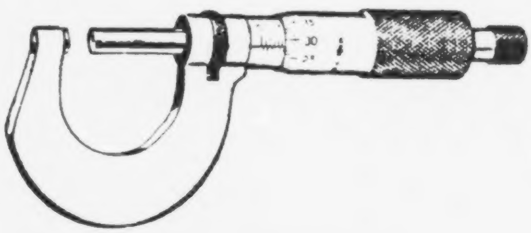
Measuring Instruments


32
1
3
4
5
16
1
3
4
5

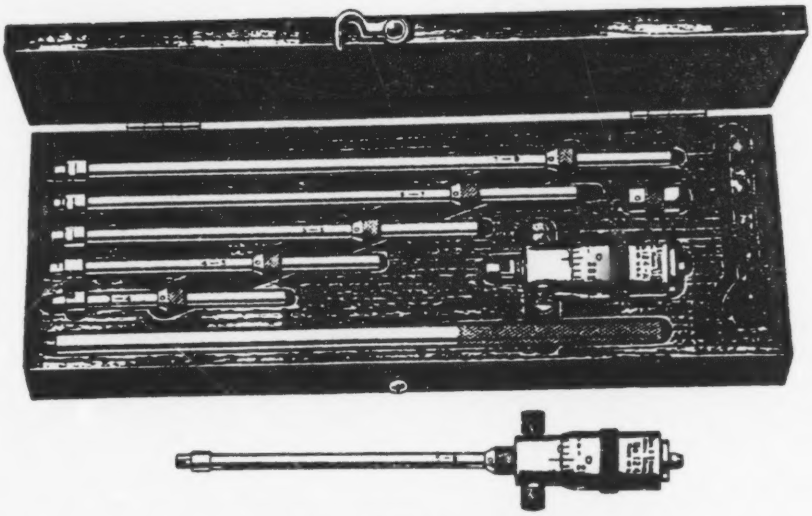
Rules



Depth Micrometer



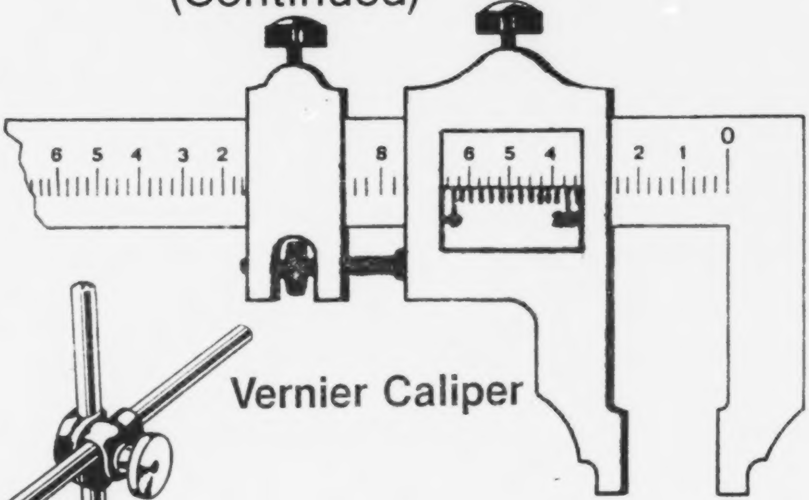
Outside Micrometer



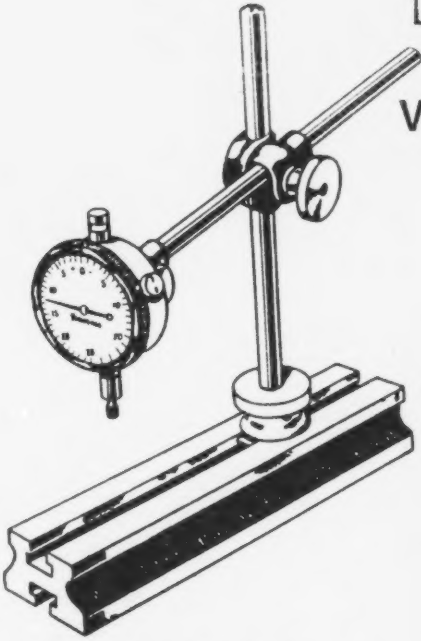
Inside Micrometer

Measuring Instruments

(Continued)

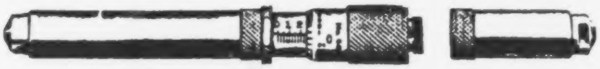

6 5 4 3 2
8
6 5 4
2 1 0

Vernier Caliper



Dial Indicator

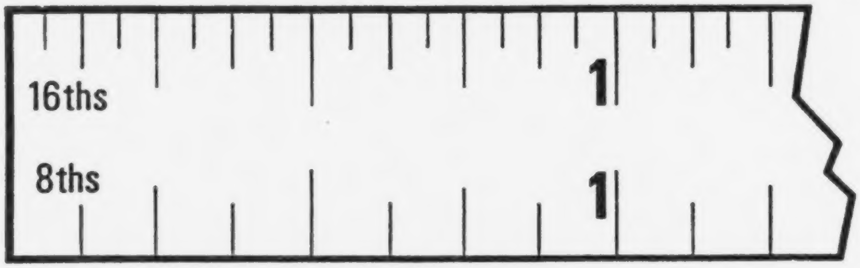
Telescoping Gauge



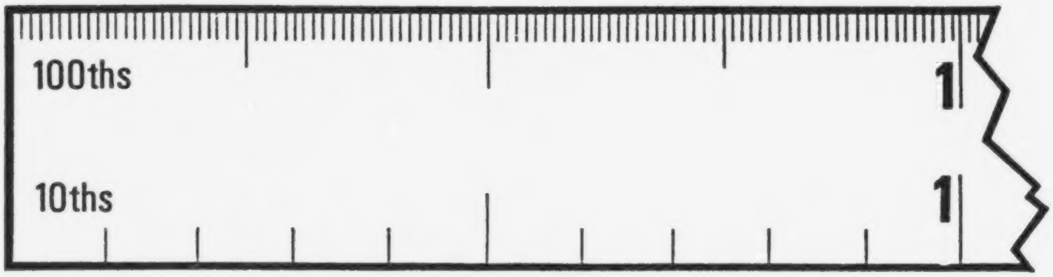
Hole Gauge

BEST COPY AVAILABLE

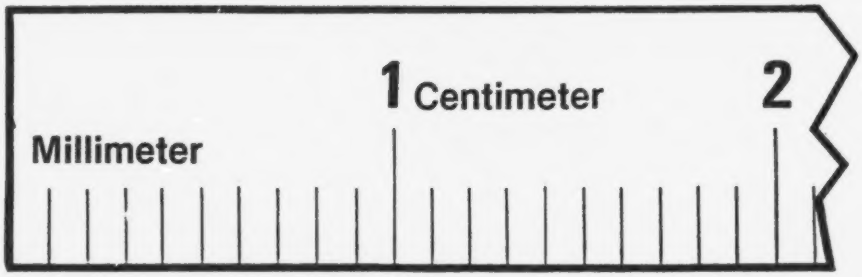
Units of Measurement


16ths
1
8ths
1

Fractional Rule

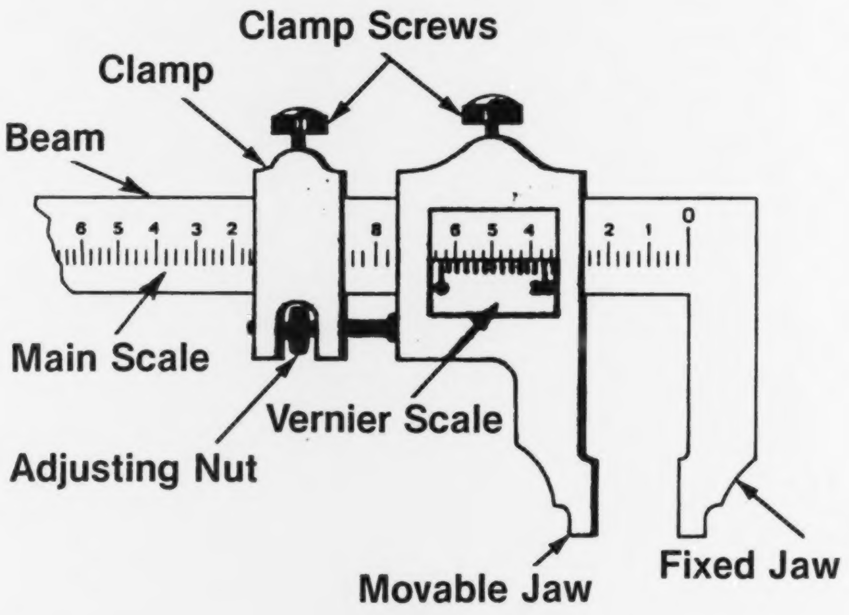

100ths
1
10ths
1

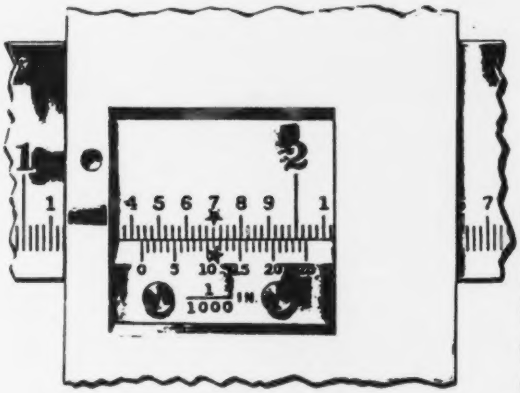
Decimal Rule


1 Centimeter
2
Millimeter

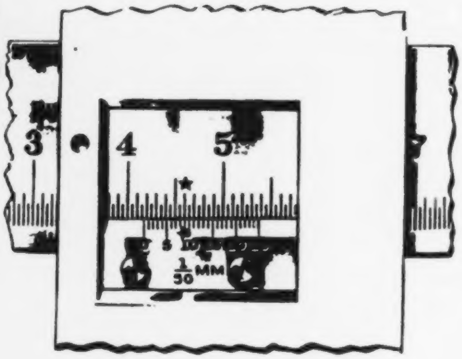
Metric Rule

Vernier Caliper Parts


Clamp Screws
Clamp
Beam
Main Scale
Adjusting Nut
Vernier Scale
Movable Jaw
Fixed Jaw

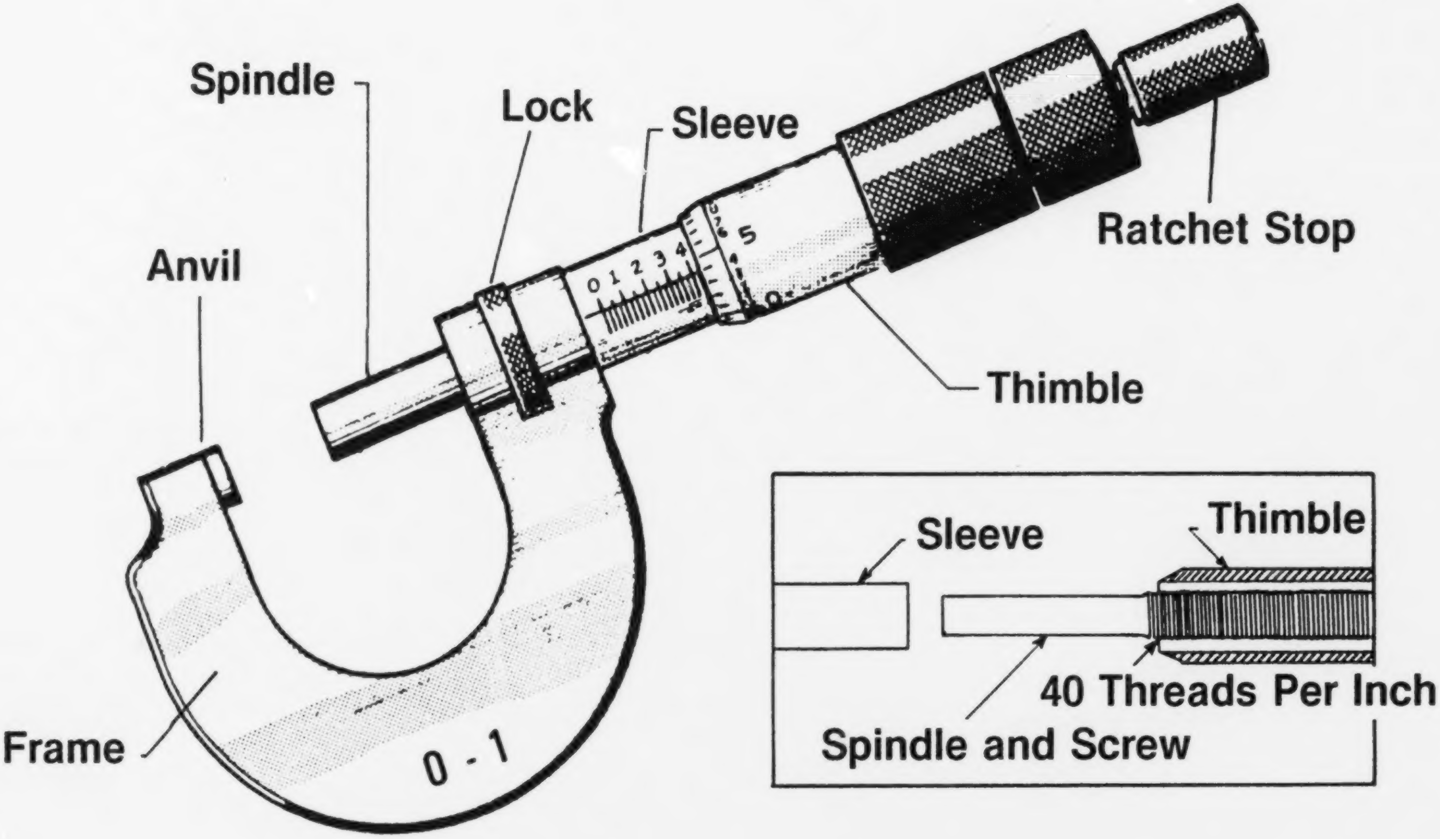


Standard Scale



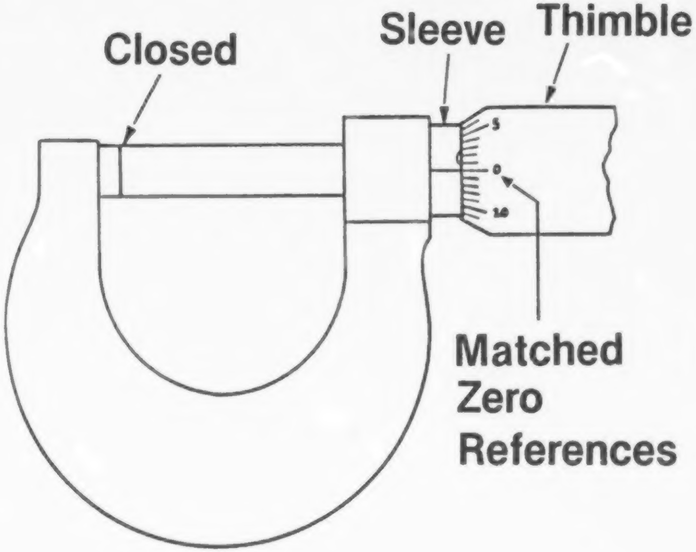
Metric Scale

Micrometer Parts

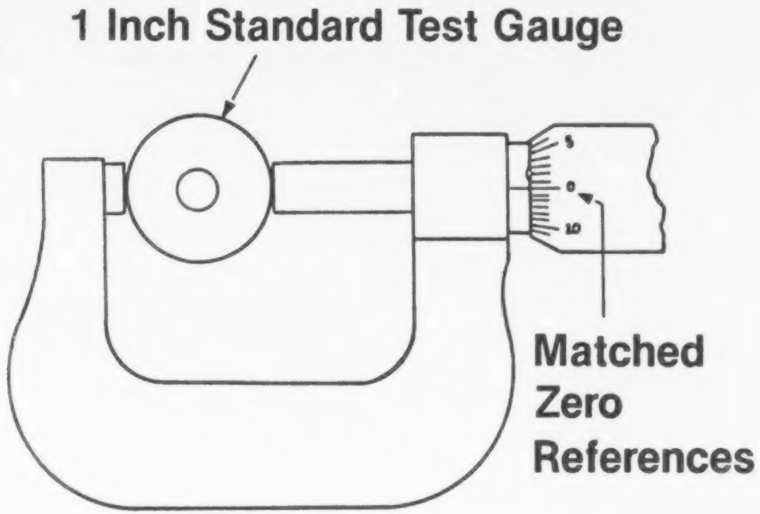

Spindle
Lock
Sleeve
Anvil
Ratchet Stop
Thimble
Frame
0 1 2 3 4
5
0 - 1
Sleeve
Thimble
40 Threads Per Inch
Spindle and Screw

TM-5

Checking the Micrometer for Accuracy

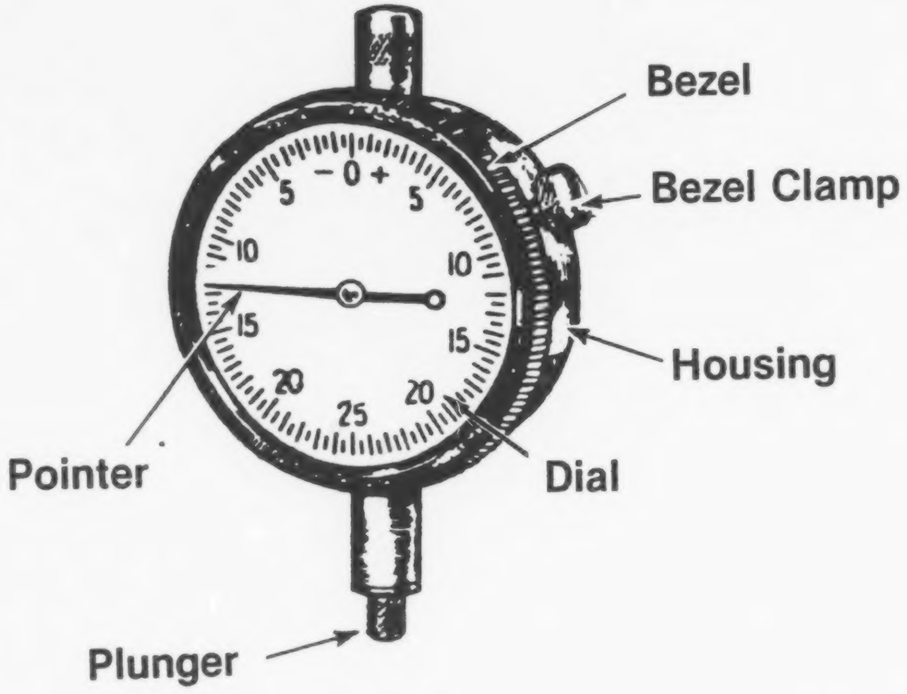

Closed
Sleeve
Thimble
5
0
10
Matched Zero References

1 Inch Micrometer

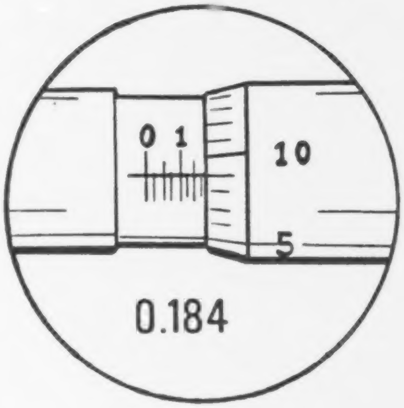

1 Inch Standard Test Gauge
5
0
15
Matched Zero References

2 Inch Micrometer

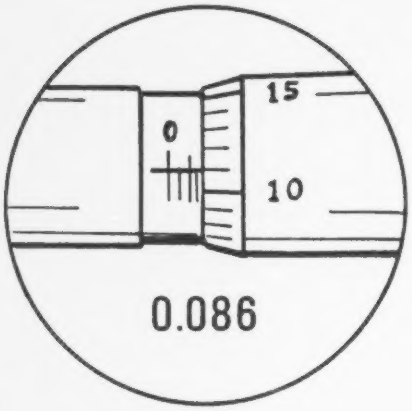
Dial Indicator Parts


Bezel
Bezel Clamp
Housing
Pointer
Dial
Plunger
5 − 0 + 5
10
10
15
15
20
25
20

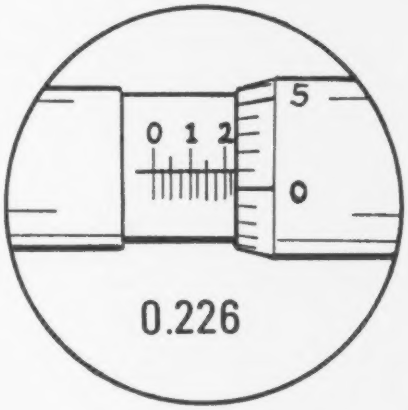
Reading a Micrometer



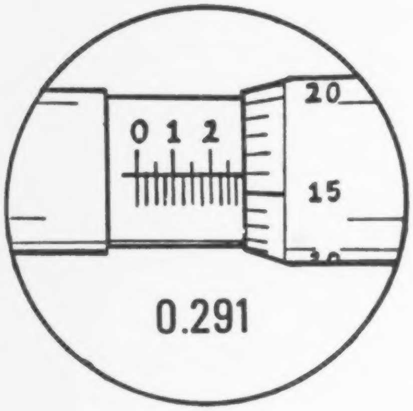
0.184



0.086

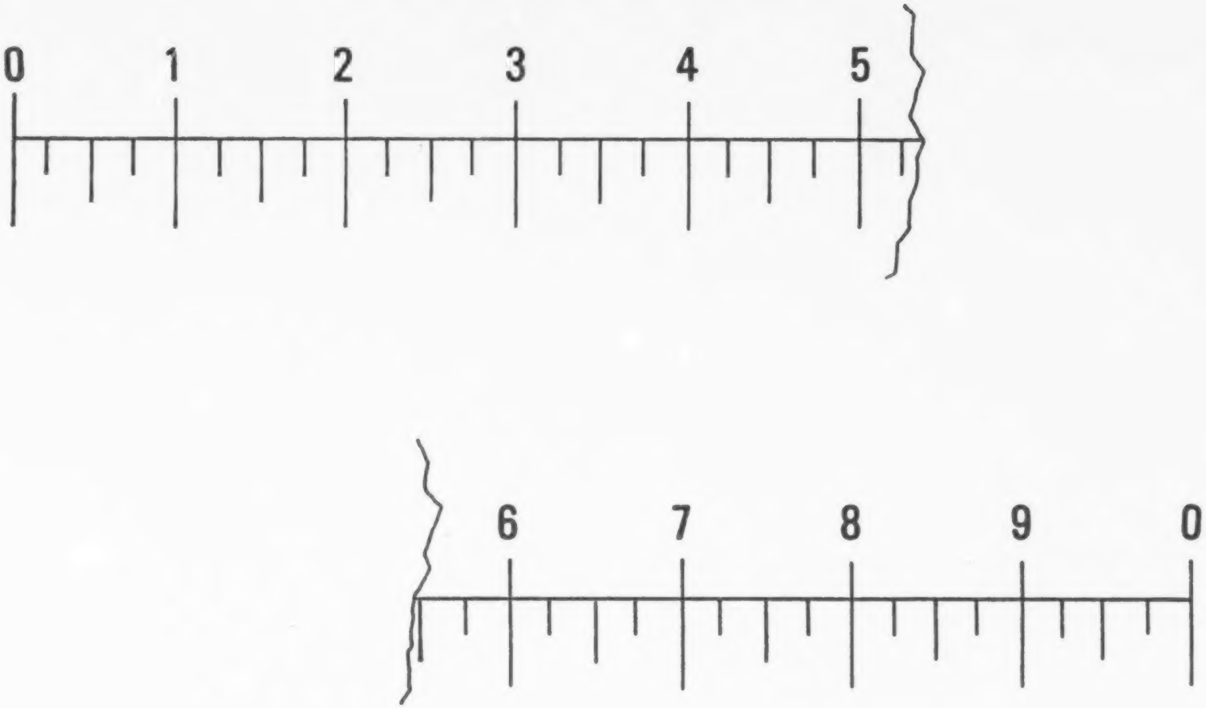


0.226



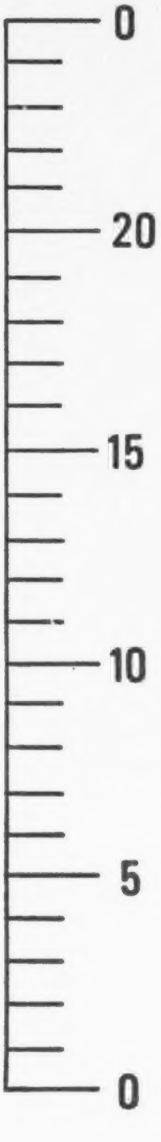
0.291

Sleeve Readings

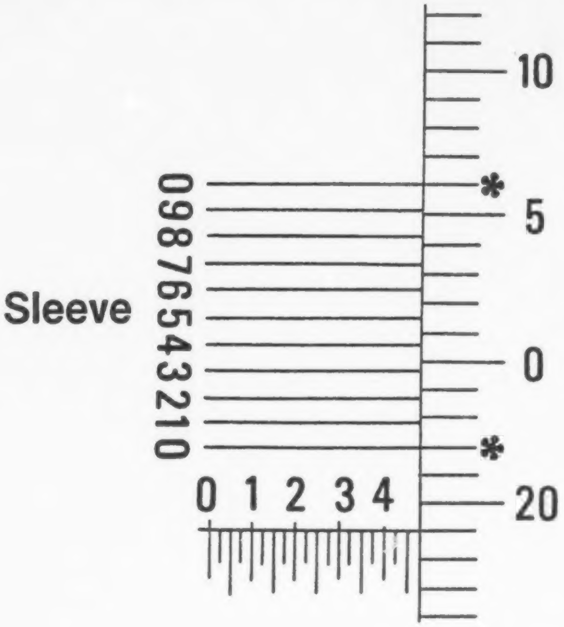

0
1
2
3
4
5
6
7
8
9
0

TM-9

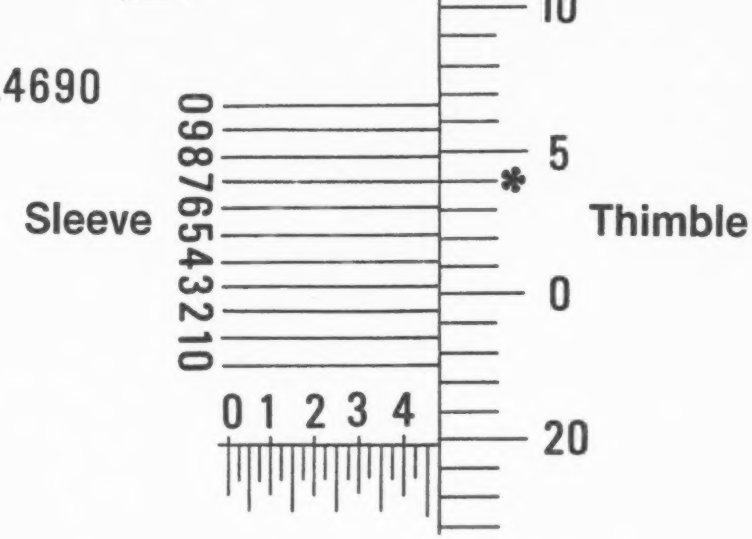
Thimble Readings



Vernier Micrometer Readings

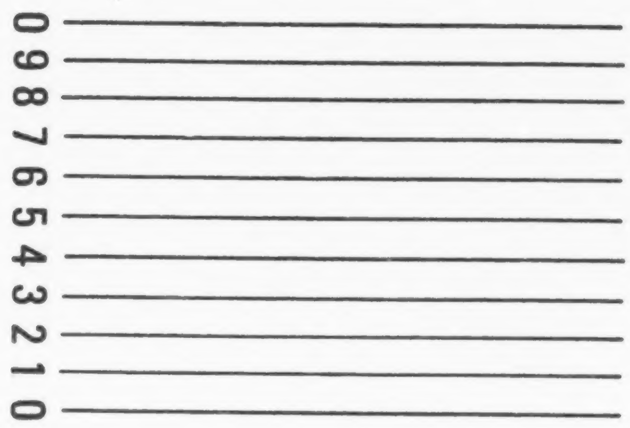

10
*
5
Sleeve
0987654321 0
Thimble
0
*
0 1 2 3 4
20

0.4690


10
5
*
Sleeve
0987654321 0
Thimble
0
0 1 2 3 4
20

0.4697

Vernier Sleeve Readings


0
9
8
7
6
5
4
3
2
1
0

Conversion Chart

Fraction - Decimal - Millimeter

4ths	8ths	16ths	32nds	64ths	to 2 places	to 3 places	to 4 places	mm
				1/64	0.02	0.016	0.0156	0.3969
			1/32		0.03	0.031	0.0312	0.7937
				3/64	0.05	0.047	0.0469	1.1906
		1/16			0.06	0.062	0.0625	1.5875
				5/64	0.08	0.078	0.0781	1.9844
			3/32		0.09	0.094	0.0938	2.3812
				7/64	0.11	0.109	0.1094	2.7781
	1/8				0.12	0.125	0.1250	3.1750
				9/64	0.14	0.141	0.1406	3.5719
			5/32		0.16	0.156	0.1562	3.9687
				11/64	0.17	0.172	0.1719	4.3656
		3/16			0.19	0.188	0.1875	4.7625
				13/64	0.20	0.203	0.2031	5.1594
			7/32		0.22	0.219	0.2188	5.5562
				15/64	0.23	0.234	0.2344	5.9531
1/4					0.25	0.250	0.2500	6.3500
				17/64	0.27	0.266	0.2656	6.7469
			9/32		0.28	0.281	0.2812	7.1437
				19/64	0.30	0.297	0.2969	7.5406
		5/16			0.31	0.312	0.3125	7.9375
				21/64	0.33	0.328	0.3281	8.3344
			11/32		0.34	0.344	0.3438	8.7312
				23/64	0.36	0.359	0.3594	9.1281
	3/8				0.38	0.375	0.3750	9.5250
				25/64	0.39	0.391	0.3906	9.9219
			13/32		0.41	0.406	0.4062	10.3187
				27/64	0.42	0.422	0.4219	10.7156
		7/16			0.44	0.438	0.4375	11.1125
				29/64	0.45	0.453	0.4531	11.5094
			15/32		0.47	0.469	0.4688	11.9062
				31/64	0.48	0.484	0.4844	12.3031
1/2					0.50	0.500	0.5000	12.7008

Conversion Chart

Fraction - Decimal - Millimeter

4ths	8ths	16ths	32nds	64ths	to 2 places	to 3 places	to 4 places	mm
				33/64	0.52	0.516	0.5156	13.0968
			7/32		0.53	0.531	0.5312	13.4937
				35/64	0.55	0.547	0.5469	13.8906
		9/16			0.56	0.562	0.5625	14.2875
				37/64	0.58	0.578	0.5781	14.6844
			19/32		0.59	0.594	0.5938	15.0812
				39/64	0.61	0.609	0.6094	15.4781
	5/8				0.62	0.625	0.6250	15.8750
				41/64	0.64	0.641	0.6406	16.2719
			21/32		0.66	0.656	0.6562	16.6687
				43/64	0.67	0.672	0.6719	17.0656
		11/16			0.69	0.688	0.6875	17.4625
				45/64	0.70	0.703	0.7031	17.8594
			23/32		0.72	0.719	0.7188	18.2562
				47/64	0.73	0.734	0.7344	18.6532
3/4					0.75	0.750	0.7500	19.0500
				49/64	0.77	0.766	0.7656	19.4469
			25/32		0.78	0.781	0.7812	19.8433
				51/64	0.80	0.797	0.7969	20.2402
		13/16			0.81	0.812	0.8125	20.6375
				53/64	0.83	0.828	0.8281	21.0344
			27/32		0.84	0.844	0.8438	21.4312
				55/64	0.86	0.859	0.8594	21.8281
	7/8				0.88	0.875	0.8750	22.2250
				57/64	0.89	0.891	0.8906	22.6219
			29/32		0.91	0.906	0.9062	23.0187
				59/64	0.92	0.922	0.9219	23.4156
		15/16			0.94	0.938	0.9375	23.8125
				61/64	0.95	0.953	0.9531	24.2094
			31/32		0.97	0.969	0.9688	24.6062
				63/64	0.98	0.984	0.9844	25.0031
1					1.00	1.000	1.0000	25.4000

ASSIGNMENT SHEET
SMALL ENGINE REPAIR

NAME______________________________ DATE____________________

UNIT: Measurement Instruments

TOPIC: Measurement and Instruments

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms on the right with their correct definitions.

_____ a. Low precision measuring instrument graduated in fractional or decimal parts of an inch

_____ b. Marking found on rules and scales to denote unit of length

_____ c. Mistake in the reading or total measurement

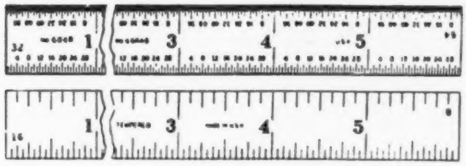
_____ d. Accurate or true measurement

_____ e. Starting point of measurement for both workpiece and rule

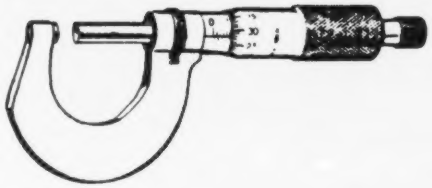
_____ f. Makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter

1. Graduation
2. Reliable measure
3. Vernier caliper
4. Steel rule
5. Reference point
6. Error

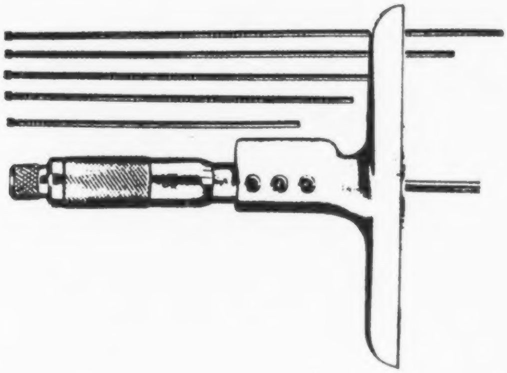
2. Identify measuring instruments used in small engine repair.



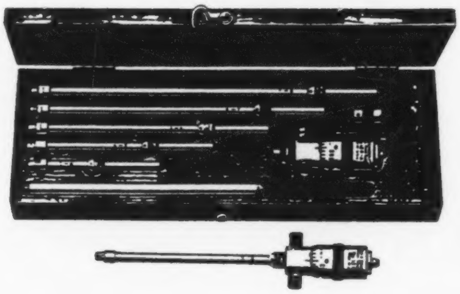
a. ____________________



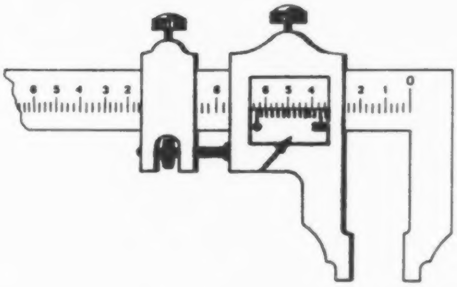
b. ____________________



c. ____________________

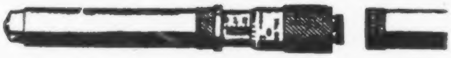


d. ____________________

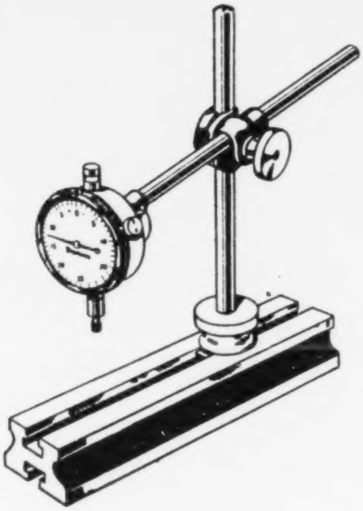


6 5 4 3 2
6 5 4
2 1 0

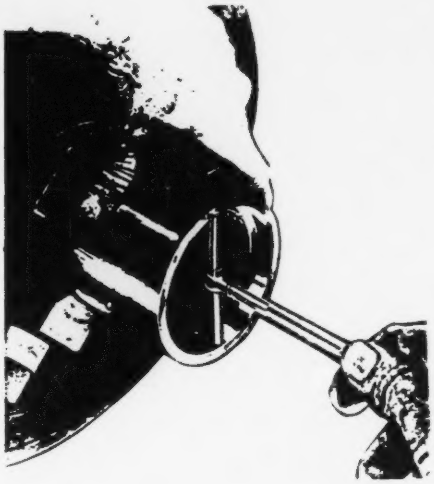
e. ____________________



f. ____________________



g. ____________________



h. ____________________

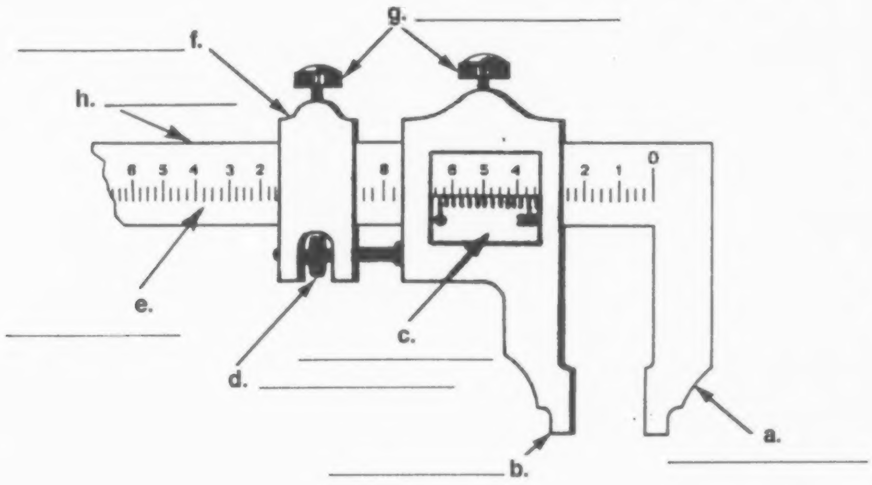
3. Complete the following list of steps for reading measuring instruments by filling in the blanks correctly.

   a. Select ____________ of the required units
   b. Total the number of ____________
   c. Count ______________ units
   d. ________________ graduations to lowest terms

4. Select basic units of measurement found on rules by placing an "X" in the appropriate blanks.

   _____ a. Fractional
   _____ b. Decimal
   _____ c. Integral
   _____ d. Metric

5. Identify the major parts of a vernier caliper.



6. Identify the major parts of an outside micrometer.

a. ______________

b. ______________

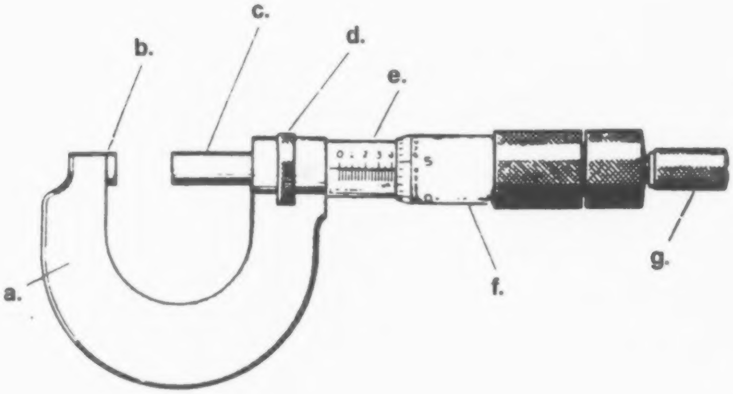
c. ______________

d. ______________

e. ______________

f. ______________

f. ______________



7. Complete the following list of statements concerning methods for checking the accuracy of outside micrometers by filling in the blanks correctly.

a. 0-in. - 1.000-in.

1) Close ________________ and anvil together

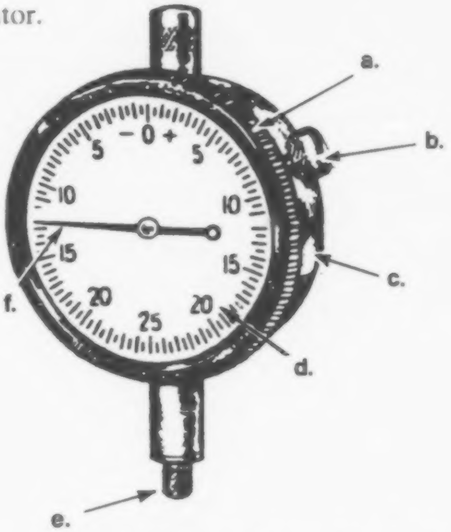
2) Observe ________________ references on the sleeve and thimble

b. More than one inch

1) Use a standard bar or disc to check the ______________ capacity

2) Observe zero references on the ______________________________ and ______________

8. Identify the major parts of a dial indicator.



a. ______________

b. ______________

c. ______________

d. ______________

e. ______________

f. ______________

9. Arrange in order the steps for set up and use of a dial indicator by placing the correct sequence numbers in the appropriate blanks.

_____a. Pre-load indicator

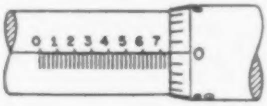
_____b. Measure work

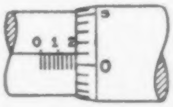
_____c. Position plunger in contact with surface to be measured

_____d. Secure dial indicator to suitable mounting fixture

_____e. Zero dial

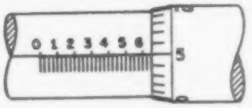
10. Read the following plain micrometer settings

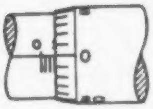




a. __________________

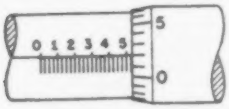
b. __________________

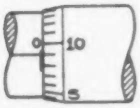




c. ______________________

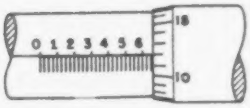
d. ______________________

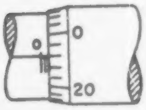




e. ______________________

f. ______________________


0 1 2 3 4 5 6
15
10



g. ______________________

h. ______________________

11. Read the following vernier micrometer settings

Answers

a. ______________

b. ______________

c. ______________

d. ______________

e. ______________

f. ______________

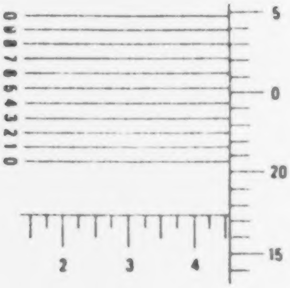
g. ______________

h. ______________

i. ______________

j. ______________

a.


0 9 8 7 6 5 4 3 2 1 0
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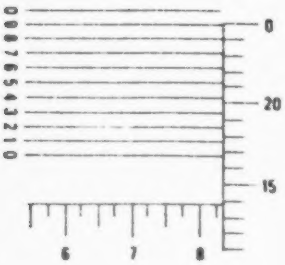
2
3
4

b.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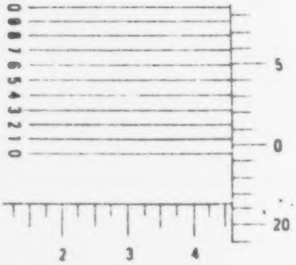
c.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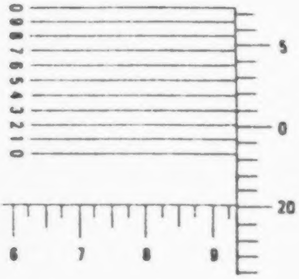
4

d.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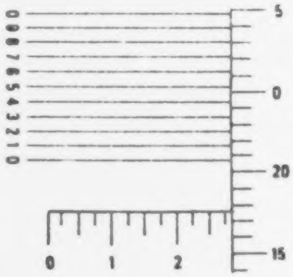
9

e.


0 9 8 7 6 5 4 3 2 1 0
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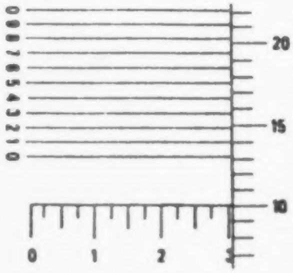
f.


0 9 8 7 6 5 4 3 2 1 0
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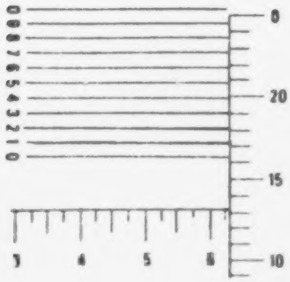
g.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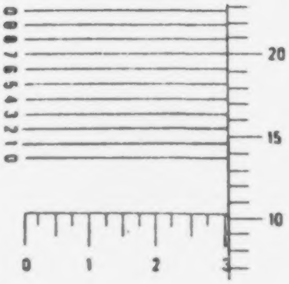
h.


0 9 8 7 6 5 4 3 2 1 0
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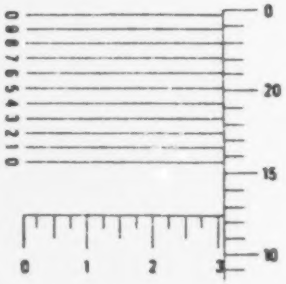
i.


0 9 8 7 6 5 4 3 2 1 0
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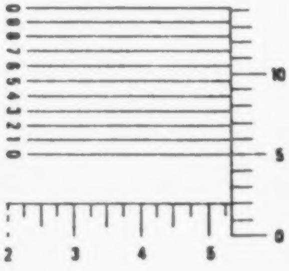
j.


0 9 8 7 6 5 4 3 2 1 0
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2
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4
5

JOB SHEET
SMALL ENGINE REPAIR

NAME________________________________ DATE____________________

UNIT: Measurement Instruments

TOPIC: Using a Vernier Caliper

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to use a vernier caliper correctly.

TOOLS AND EQUIPMENT:
Vernier caliper
Workpieces
Assortment of fractional drill bits
Assortment of letter size drill bits
Assortment of machined parts

GENERAL INSTRUCTIONS: Follow procedures to use a vernier caliper properly.

PROCEDURES AND/OR TASKS:

1. Select workpieces that are smooth and free of burrs, nicks, or dents.
2. Clean inside face of caliper jaws.
3. Check vernier caliper at O reference.
4. Open caliper greater than thickness of part to be measured.
5. Hook end jaw over part to be measured.
6. Slide movable jaw into contact with part.
7. Tighten clamp screw on fine adjustment nut.

8. Make fine adjustment with the fine adjusting screw, if necessary.
9. Tighten clamping screw above vernier plate.
10. Remove caliper from work carefully.
11. Read caliper.
12. List readings according to letter or number on workpieces.
13. Return vernier caliper to correct storage place.
14. Hand in the listed readings to instructor for evaluation.

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JOB SHEET

SMALL ENGINE REPAIR

NAME______________________________________**DATE**____________________

UNIT: Measurement Instruments

TOPIC: Using a Plain Micrometer

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to use a plain micrometer correctly.

TOOLS AND EQUIPMENT:

Micrometers, plain
  a. 0-in. - 1.000-in. size
  b. 1.000-in. - 2.000-in. size
Lathe or vise
Workpieces
  a. New fractional drill bits, assortment of 5
  b. New letter size drill bits, assortment of 5
  c. Pieces of metal, such as cold rolled stock, machined parts, hardened dowels; assortment of 5

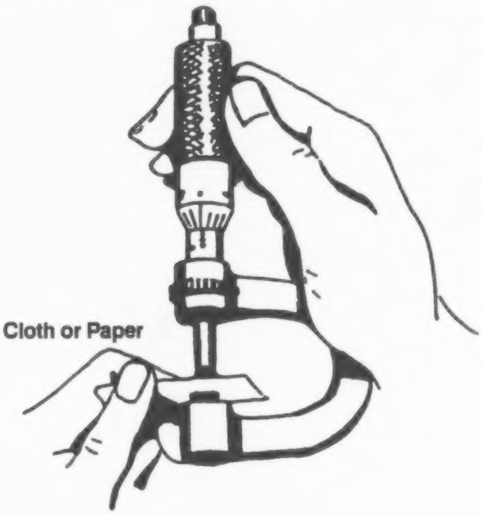
Note: *All workpieces should be numbered or lettered for reference.*

GENERAL INSTRUCTIONS: Follow procedures to use a micrometer properly.

PROCEDURES AND/OR TASKS:

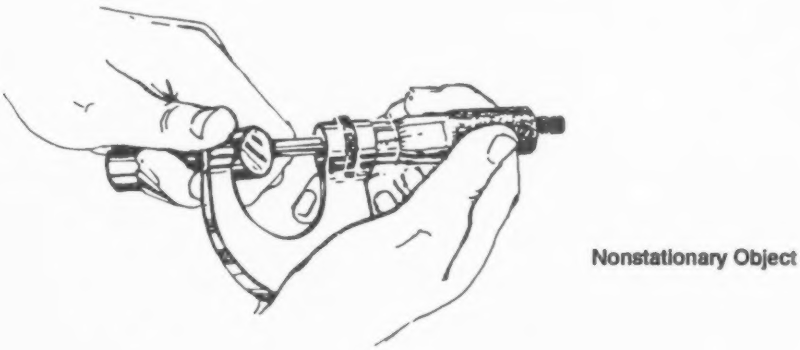
1. Select workpieces that are clean and free of burrs, nicks, of dents.
2. Select the proper size micrometer for the workpiece.

3. Clean the spindle and anvil of the micrometer.

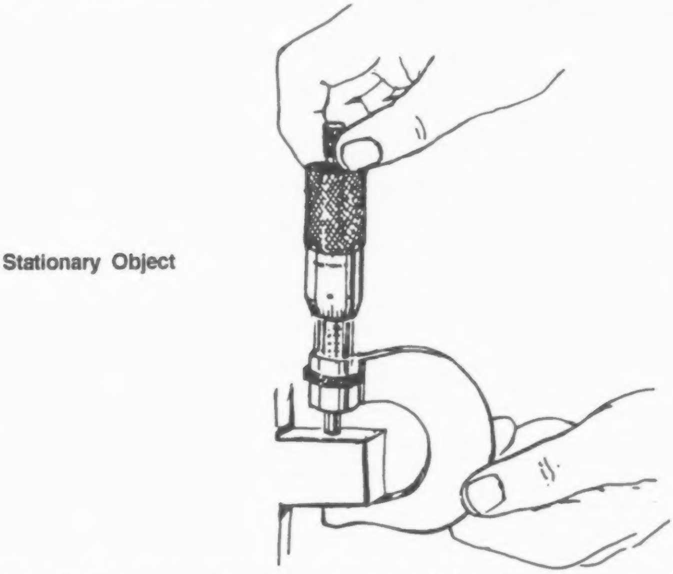

Cloth or Paper

4. Check the micrometer at 0 reference.

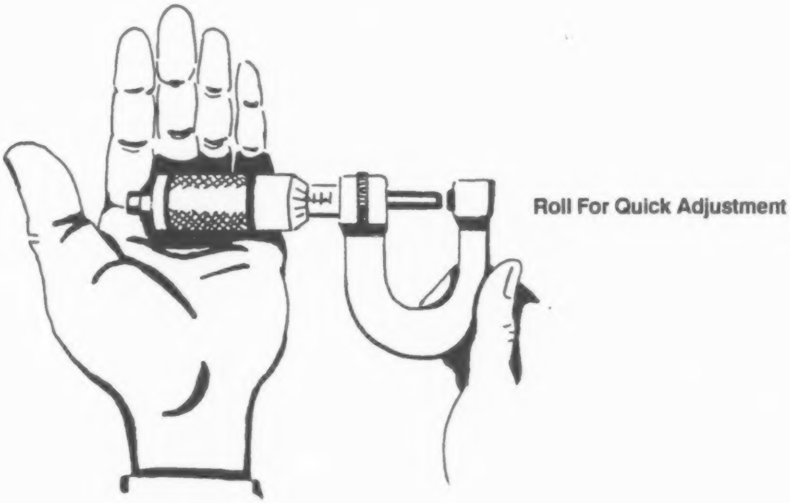
5. Hold the micrometer according to the type of workpiece.
   a. Hold the micrometer in the right hand and the workpiece in the left hand to measure a nonstationary object.


Nonstationary Object

b. Hold the micrometer in both hands to measure a stationary object

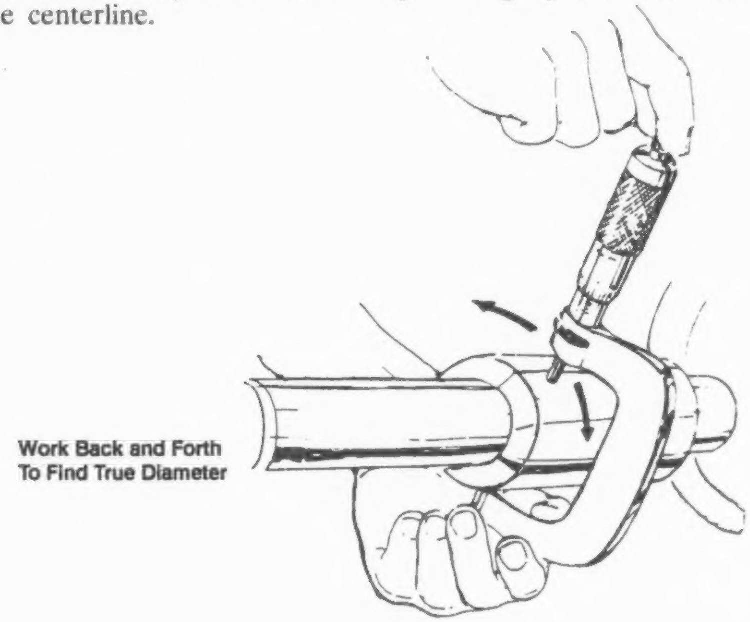

Stationary Object

Note: *Roll micrometer along palm of hand or forearm for quick adjustment.*


Roll For Quick Adjustment

6. Place the micrometer directly over the center of the workpiece to be measured.
7. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece.

8. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true centerline.



9. Use ratchet stop or light sense of feel to determine exact measurement.

10. Observe micrometer readings.
Note: *Spindle lock can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.*

11. List the readings according to the letter or number on the workpiece.

12. Return the micrometer to its correct storage.
Note: *The spindle and anvil of the micrometer should be left open when stored.*

13. Hand in the listed readings to the instructor for evaluation.

JOB SHEET
SMALL ENGINE REPAIR

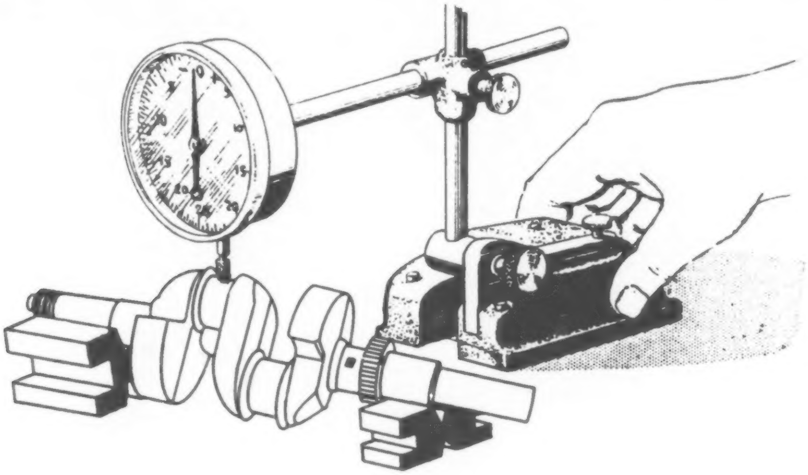
NAME ____ **DATE** ______________________

UNIT:	Measurement Instruments
TOPIC:	Using a Dial Indicator
ESSENTIAL ELEMENT(S):	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)
SPECIFIC OBJECTIVE(S):	After completing this lesson, the student(s) will be able to use a dial indicator correctly.
TOOLS AND EQUIPMENT:	Dial indicator Dial indicator holder Magnetic base Two V blocks Appropriate assortment of machined parts **Note:** *All workpieces should be numbered or lettered for reference.*
GENERAL INSTRUCTION:	Follow procedures to use a dial indicator properly.

PROCEDURES AND/OR TASKS:

1. Select workpieces that are clean and free of burrs, nicks, or dents.
2. Attach dial indicator to holder.
3. Secure holder to work surface.

4. Mount crankshaft according to type of measurement to be made.



5. Position holder so that dial indicator plunger contacts workpiece.
6. Adjust holder so that plunger is depressed two revolutions of pointer and tighten holder.
7. Rotate bezel until the zero marking is in line with pointer.
8. Measure workpiece for taper, concentricity, and run-out.
9. List readings according to the letter or number on the workpiece.
10. Disassemble dial indicator and holder and return to the correct storage.
11. Hand in the listed readings to the instructor for evaluation.

JOB SHEET

SMALL ENGINE REPAIR

NAME ________________________________ **DATE** ____________________

UNIT: Measurement Instruments

TOPIC: Using a Telescoping Gauge

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to use a telescoping gauge correctly.

TOOLS AND EQUIPMENT:

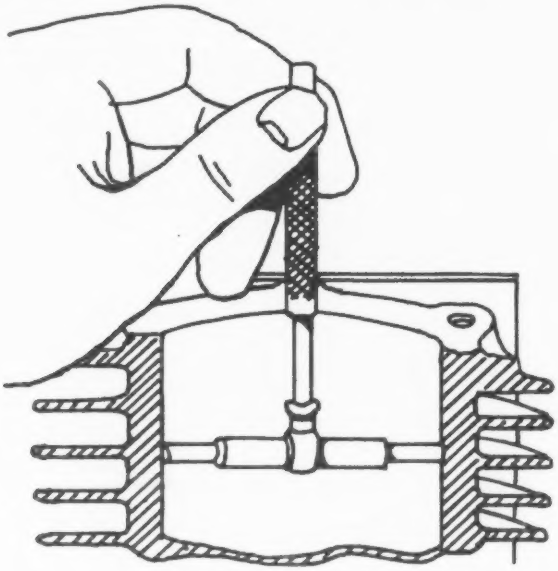
Micrometer	Shop towels
Telescoping gauge	Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to use a telescoping gauge properly.

PROCEDURES AND/OR TASKS:

1. Secure cylinder from instructor to be measured.
2. Compress the arms of the telescoping gauge with your hand into a size slightly smaller than the cylinder to be measured, and tighten the nut to lock the arms in position.

3. Insert the gauge into the cylinder; loosen the nut.
   Note: *A light spring inside the arm will push the adjustable end out to fit the cylinder.*



4. Make sure the telescoping end is at right angles to the cylinder wall.

5. Tighten the nut and withdraw the gauge.

6. Measure the telescoping gauge setting with a micrometer.

7. Have your instructor check your work.

8. Return tools and materials to their proper places.

STUDENT INFORMATION SHEET

SMALL ENGINE REPAIR

UNIT: Troubleshooting

TOPIC: Troubleshooting

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B), (ddd)(2)(C), (ddd)(2)(D), (ddd)(2)(E)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to define and discuss troubleshooting problems and how to repair problems correctly.

SPECIFIC OBJECTIVE(S): After completing this information sheet, the student(s) will be able to define and describe how to troubleshoot, read a troubleshooting chart, and check fuel, ignition, and compression problems in order to repair them correctly.

BASIC ACADEMIC SKILLS APPLICATIONS: *Basic academic skills used when troubleshooting the small engine include mathematical principles, oral and written communication skills, the application of reading concepts and skills, and science.*

Basic Problems

The engine must have **fuel ignition** and **compression** in order to operate. The engine that does not get enough or gets too much fuel will not start. The loss of ignition or ignition at the wrong time does not allow the fuel mixture to ignite. If the air-fuel mixture is incorrect or compressed too lightly on the compression stroke, there will be no explosion for a power stroke.

Ignition System

If the engine has a magneto problem, it will not produce the high voltage spark needed to start the engine. To check for spark, remove the plug wire from the spark plug. A spark plug tester may be used to look for ignition. Hold the spark plug wire on the tester. Hold the handle on the spark tester, then touch the other end to the plug. Use your other hand to turn the flywheel. A spark should jump across the gap of the tester.

If the spark jumps the gap, the magneto is working. If the engine still will not start, the problem must be in some other part. The spark also could be checked by holding the spark plug wire close to the plug, then turning the flywheel to see if the spark will jump from the plug to the metal end of the wire. Be careful not to touch the metal end while checking for spark with this method. If you touch the terminal, you will get a shock. When you spin the flywheel and the spark jumps across from the terminal to the plug, the magneto is working.

If the engine does not have a good strong spark, the ignition system will need to be checked further. The mechanic will have to test and repair, as necessary, each part of the ignition system. Start by removing the plug, cleaning it, checking the gap, and replacing the plug in the head. If the plug is nicked or the threads are damaged, replace the plug.

If the engine doesn't start yet, remove the flywheel and check the **breaker points** and **condenser**. If the point surface is burned or damaged, replace with new points and condenser, and reassemble.

Fuel System

The engine must have the correct amount of fuel to start and run. Too much or too little fuel will cause the engine to run roughly.

To check for fuel problems, remove the spark plug and look at the electrode. If the fuel mixture is correct, the spark plug will look brown or tan in color. If the plug does not look like this, there could be a fuel problem. If the plug is black or damp, there is too much fuel. If the plug is dry and white, there is not enough fuel. If the plug is black, check the choke valve be sure it is open. If it is partially closed, the engine will get too much fuel. Replace the plug and try to start the engine. Be sure the choke valve is not sticking.

If an engine does not have enough fuel, the plug will be dry and white in color. Remove the cap on the fuel tank. If the gas smells like varnish, the carburetor may be stopped up and not allowing the fuel to come through. Also check the tank valve. Sometimes dirt, water, or even grass may get in the tank and clog the fuel line. If the fuel line has a screen or filter, check to see if it is clogged up. A plugged fuel cap vent can stop fuel from getting to the carburetor. Check the high-speed and low-speed adjustment screws to be sure they are set correctly.

Compression

Even though the engine may have fuel and ignition, without enough compression, it still will not operate. The air-fuel mixture must be compressed tightly or there will be no power stroke. After checking for ignition and fuel, the mechanic must check the compression.

To check for compression, remove the spark plug. The spark plug wire should be grounded away from the spark plug hole. The mechanic can hold his thumb over the hole and then pull the starter rope to turn the engine over. There should be a strong push against the thumb on each compression stroke. If not, the compression is too low to start the engine.

A compression gauge can be put in the spark plug hole of a cylinder. The compression pressure is read on the gauge as the engine is cranked. The compression test will tell the condition of the rings, valves, and head gasket. The results of the reading should be compared with the specifications in the manufacturer's manual. This will tell the mechanic if the cylinder is working correctly.

Worn piston rings are an indication of low compression on the first stroke, which will tend to build up on the strokes that follow.

Valve problems are indicated by low compression readings on the first stroke, which does not build up rapidly on following strokes. Leaking head gaskets give the same type of reading as valve problems do.

Troubleshooting Chart

The troubleshooting chart will help save the mechanic time in locating problems. This saves the customer money and helps the mechanic repair the engine.

Manufacturers usually have a troubleshooting chart in their service manuals. The chart lists problems that occur most frequently and their possible causes. Solutions for the problems are listed beside each cause. When the mechanic uses the troubleshooting chart, it should be checked following the recommended steps. It is best to use a troubleshooting chart in a service manual that pertains to the specific engine being serviced.

The chart on TM-2 suggests some helpful ways to check out problems with the small engine.

Terms and Definitions

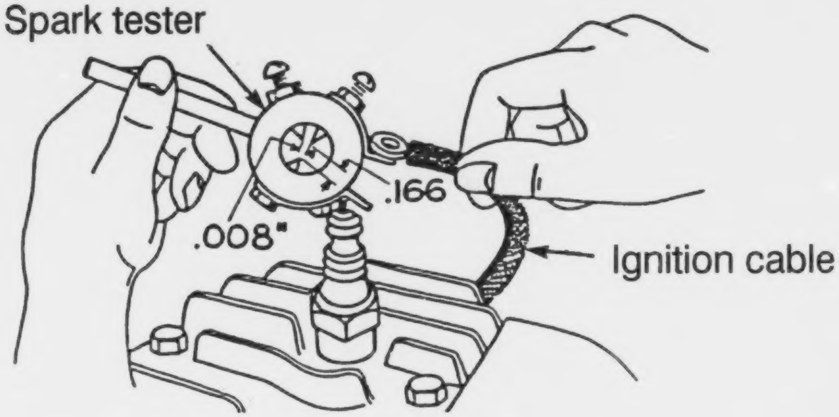
Compression gauge determines the amount of pressure of a given cylinder.

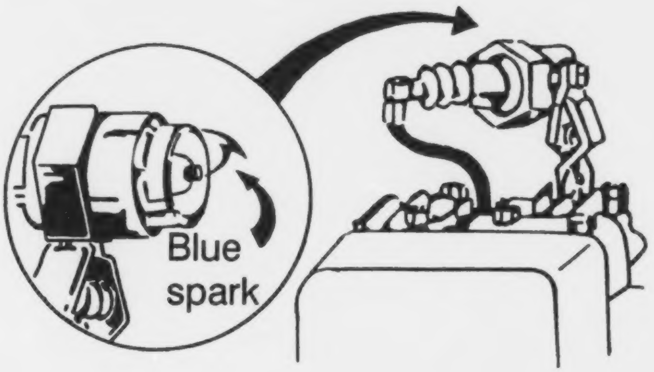
Knock is a noise generally indicating engine problems.

Troubleshooting is a step-by-step procedure to locate an engine problem.

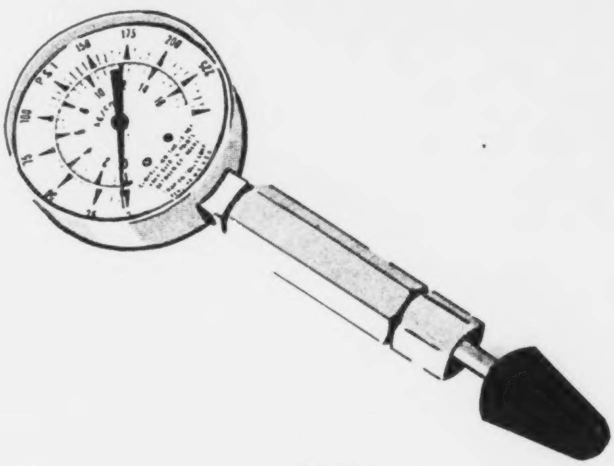
Troubleshooting chart is a list of problems along with causes and solutions.

Spark Tester


Spark tester
.166
.008"
Ignition cable



Compression Gauge



Small Engine Troubleshooting Chart

Engine Will Not Start

- Low Compression
  - valve stuck open
  - carbon on valve seat
  - loose spark plug
  - worn bore or rings
  - defective piston
  - burned valves
  - incorrect valve clearance
  - defective reed valve
  - loose head bolts
  - blown head gasket
  - piston rings stuck
  - broken connecting rod
- Fuel Problems
  - Plug Wetted Out
    - choke stuck or overused
    - stale fuel
    - float stuck open
    - mixture too rich
    - defective spark plug
    - water in fuel
    - excessive oil in two-stroke mixture
    - air cleaner dirty or saturated with fuel
  - No Fuel in Carb
    - fuel tank empty
    - fuel valve shut off
    - carb float valve stuck or clogged
    - blocked fuel filter
    - blocked fuel line
    - fuel tank vent plugged
  - Spark Plug Dry
    - choke not closing
    - intake manifold leak
    - diaphragm-type carb not pumping fuel
    - jets dirty
    - crankcase leaking on two-stroke type
- Ignition Troubles
  - No Spark at Plug
    - kill button or wires grounded out
    - points corroded
    - condenser shorted
    - high-voltage wire shorted or open
    - defective magneto armature (coil)
    - point plunger stuck
  - Weak Spark at Plug
    - point gap incorrect
    - magneto air gap too wide
    - defective condenser
    - defective magneto armature (coil)
    - defective lighting circuit

Engine Starts But Runs Poorly

- Lacks Power
  - timing incorrect
  - point gap incorrect
  - clogged muffler or exhaust port
  - carb out of adjustment
  - low compression
  - not getting full throttle
  - governor defective
  - dirty air cleaner
- Engine Vibrates
  - bent crankshaft
  - blower out of balance
  - worn drive couplings
  - attachments such as mower blades out of balance
- Engine Smokes Excessively
  - High Oil Consumption
    - loose flywheel
    - wrong oil used
    - oil diluted from rich mixture
    - engine overheating
    - worn rings or bore
    - burned piston
    - clogged crankcase breather
    - wrong fuel/oil mix on two-cycle type
  - Overheating Engine
    - cooling fins blocked
    - engine overloaded
    - ignition timing late
    - dirty cooling blower
    - clogged muffler
    - governor out of adjustment allowing overspeed
    - piston or rings fitted too tight

Hard Starting (Kick Back)

- loose blade or accessories
- armature air gap
- sheared key
- ignition timing
- starter rope length

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III-6-AS

ASSIGNMENT SHEET
SMALL ENGINE REPAIR

NAME ____ **DATE** ______________________

UNIT: Troubleshooting

TOPIC: Troubleshooting

DIRECTIONS: Read and answer the following questions in the space provided.

1. Define troubleshooting.

2. Explain the value of a troubleshooting chart.

3. Select the necessary requirements for an engine to run. Check the appropriate blanks.
   a. ______Ignition
   b. ______Speed
   c. ______Compression
   d. ______Fuel
   e. ______Centrifugal force
   f. ______Pulley

4. Place a "√" beside true statements concerning the importance of understanding troubleshooting procedures.
   a. ______Saves the customer money
   b. ______Ensures a better repair job since the total engine is observed
   c. ______Ensures better operating dependability
   d. ______Fewer employees are needed to operate a shop
   e. ______Good service means continued business with present customers, plus attracting new customers
   f. ______Makes employees more valuable because less work is returned

5. Use a troubleshooting chart to solve these problems.
   a. The equipment has been running for 45 minutes and the engine shuts down.

   b. The engine starts to vibrate excessively.

   c. Engine has just received an ignition tuneup, and was in top starting and running order when given to the customer. Two days later, the customer can not start the engine.

   d. Engine is hard to start and has a kick back.

   e. No fuel found in the carburetor.

   f. Engine is beginning to lose power (Two-Cycle).

   g. Engine starts to smoke excessively and use oil.

   h. Engine starts to overheat and begins to smoke.

JOB SHEET
SMALL ENGINE REPAIR

NAME ______________________________ DATE __________________

UNIT: Troubleshooting

TOPIC: Troubleshooting the Fuel System

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B), (ddd)(2)(C), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to troubleshoot the fuel system correctly.

TOOLS AND EQUIPMENT:
Basic hand tool assortment
Appropriate service manual
Safety glasses

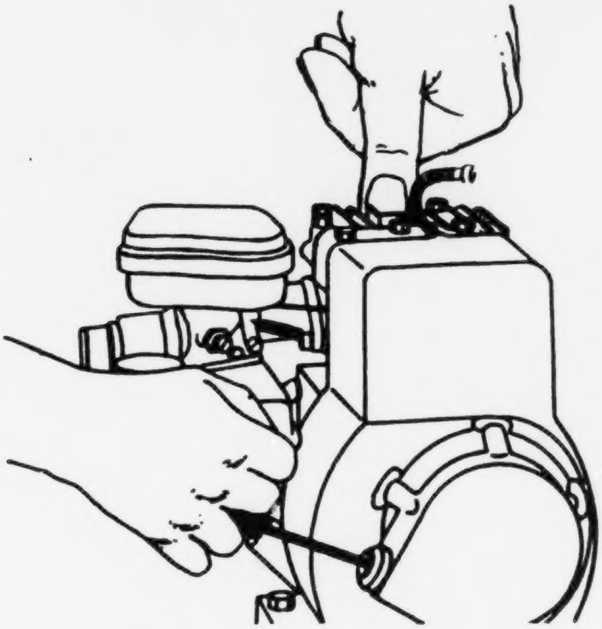
GENERAL INSTRUCTIONS: Follow procedures to troubleshoot the fuel system properly.

PROCEDURES AND/OR TASKS: Check manufacturer's manual for specifications.
Note: *Follow safety procedures.*

1. Wear proper safety equipment.
2. Read operator's manual.
3. Organize work station.

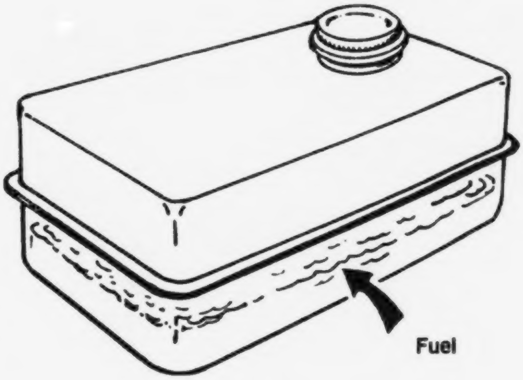
674

4. Remove the spark plug and place your thumb or finger over spark plug hole.

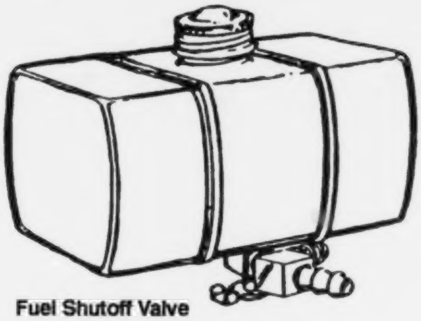


5. Pull the starter two to three times.
   Note: *Your finger should be wet if fuel is getting to the combustion chamber. When finger is dry, you will need to check further for a fuel problem.*

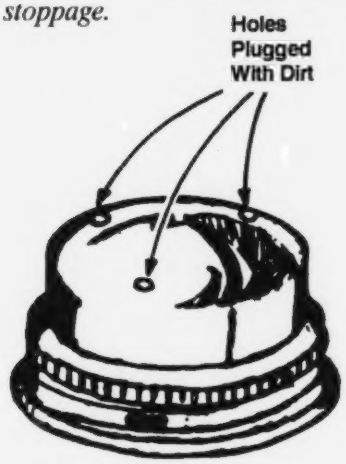
6. Check for fuel in the fuel tank.



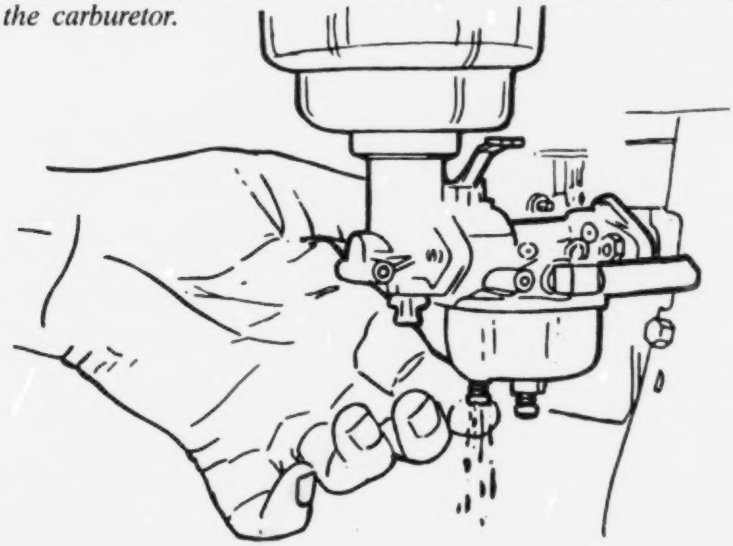
7. Check to see if fuel shutoff valve is open.



8. Check for plugged vents on fuel tank cap.
Note: *A plugged vent will cause excessive vapor pressure to build up in the tank and result in engine stoppage.*



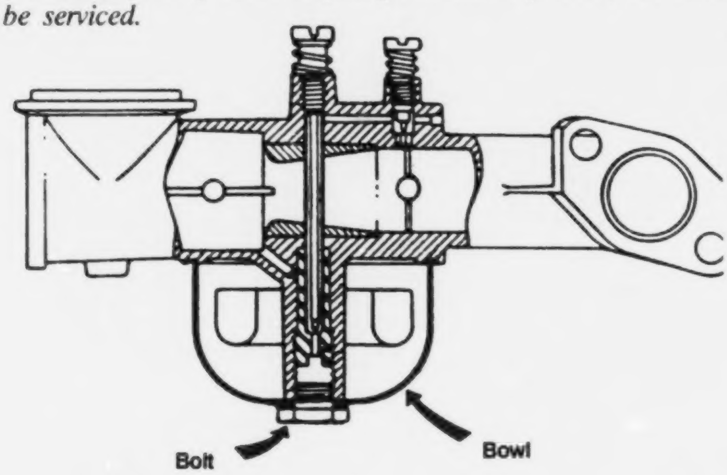
9. If the carburetor is equipped with a bowl drain valve, press the valve and let a small amount of fuel drain out into a container.
Note: *When fuel drains from the valve, this indicates that fuel is getting from the tank to the carburetor.*



BEST COPY AVAILABLE

10. If carburetor is not equipped with a drain valve, remove the bowl from the carburetor; loosen bolt or nut from bowl drain and check for gas in bowl.

    Note: *When checking the carburetor bowl for fuel, always look for water or foreign matter in the fuel. If water or foreign matter is present, the carburetor will need to be serviced.*



11. If fuel does not drain out of the valve or is not present in the bowl, check the fuel tank, line, and carburetor because this indicates an obstruction.

12. Check fuel filter for dirt or clogged element; remove and replace with a new inline filter in any flexible fuel line having ¼-in. inside diameter.

13. Formulate problem and corrective measures.
    a. Review list of probable causes.
    b. Correct fuel problem.

III-6-JS-2

JOB SHEET

SMALL ENGINE REPAIR

NAME ______________________________ DATE ____________________

UNIT: Troubleshooting

TOPIC: Troubleshooting the Ignition System

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B), (ddd)(2)(C), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to troubleshoot the ignition system correctly.

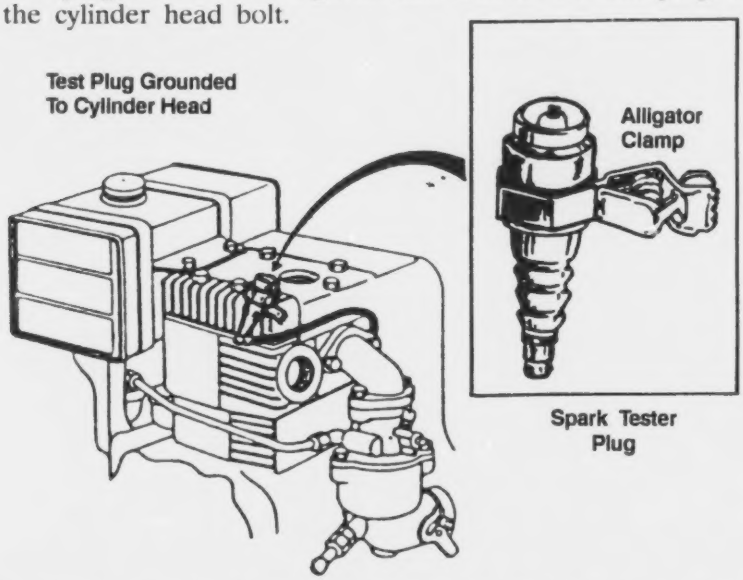
TOOLS AND EQUIPMENT:
Basic hand tool assortment
Test plug
Appropriate service manual
Safety glasses

GENERAL INSTRUCTION: Follow procedures to troubleshoot the ignition system properly.

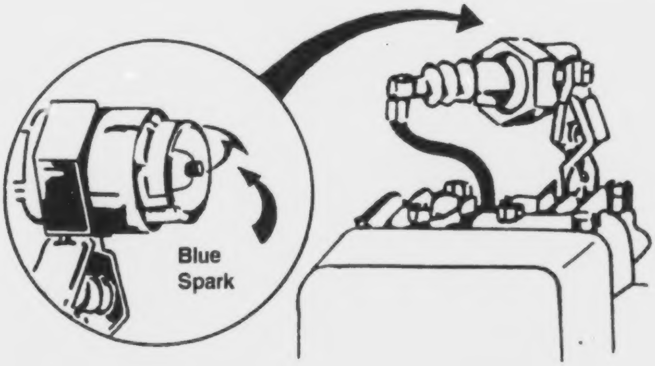
PROCEDURES AND/OR TASKS: Check manufacturer's manual for specifications.

1. Wear proper safety equipment.
2. Read operator's manual.
3. Organize your work station.
4. Disconnect the high-tension lead (spark plug wire) and remove the spark plug.

5. Using a test plug, connect the high tension lead to the test plug, and ground test plug to the cylinder head bolt.


Test Plug Grounded To Cylinder Head
Alligator Clamp
Spark Tester Plug

6. Crank the engine two to three times and observe the spark at the test plug.
   a. The spark should jump the gap and be a bright blue color; this indicates the ignition system is functioning properly.
   b. A spark that does not jump the gap from the shell to the center electrode indicates ignition problems.
   c. A spark that jumps the gap but is yellow in color indicates poor ignition; the ignition system must be serviced.



7. Formulate problems and corrective measures.
   a. Review list of probable causes.
   b. Correct ignition problem.

JOB SHEET

SMALL ENGINE REPAIR

NAME ______________________________ **DATE** ____________________

UNIT: Troubleshooting

TOPIC: Troubleshooting Engine Compression

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(2)(A), (ddd)(2)(B), (ddd)(2)(C), (ddd)(2)(D), (ddd)(2)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, students will be able to troubleshoot engine compression correctly.

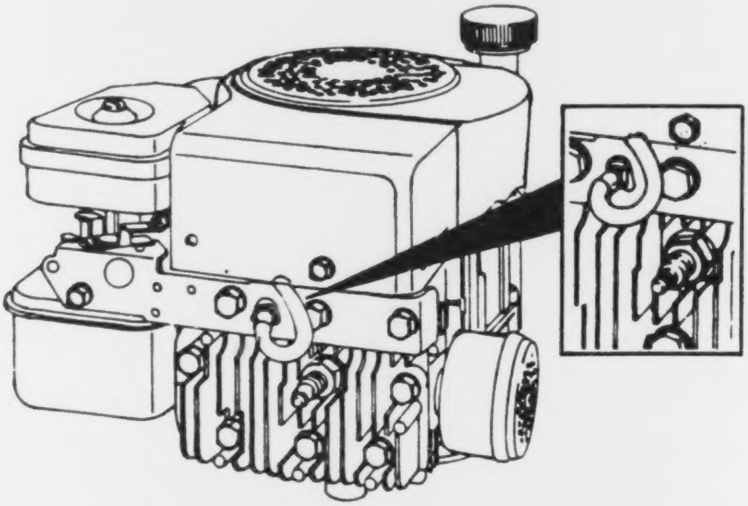
TOOLS AND EQUIPMENT:
Basic hand tool assortment
Compression gauge
Service manual
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to troubleshoot engine compression properly.

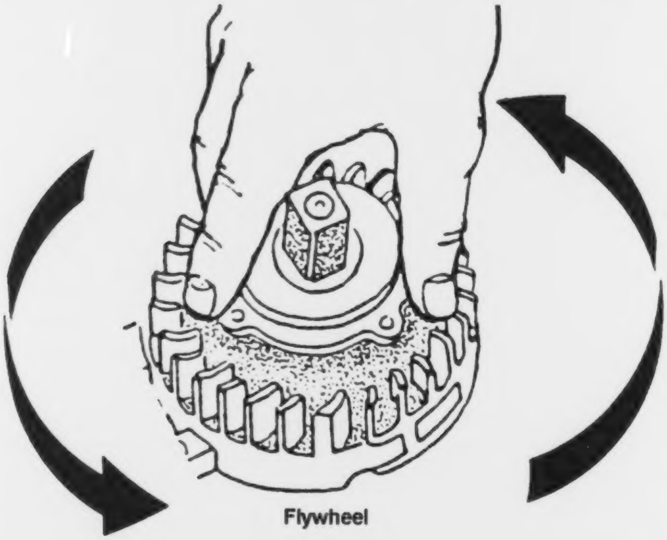
PROCEDURES AND/OR TASKS: Check manufacturer's manual for specifications.

1. Wear proper safety equipment.
2. Read operator's manual.
3. Organize your work station.

4. Remove the high-tension lead from the spark plug and secure.

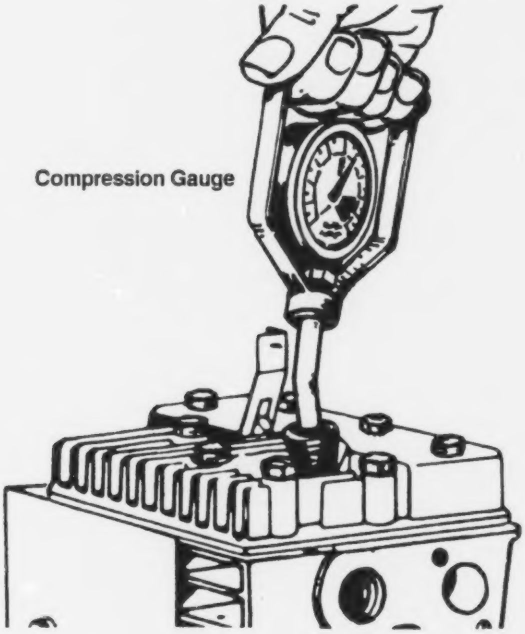


5. Manually spin the flywheel counterclockwise against the compression stroke; a sharp rebound indicates satisfactory compression; slight or no rebound indicates poor compression.



Note: *Briggs and Stratton engines are equipped with easy spin cam. Rotate the flywheel counterclockwise; a sharp rebound indicates good compression.*

6. Check the engine compression with a compression gauge.
7. Crank the engine at least six times, and read the compression gauge.



8. Formulate problems and corrective measures.
   a. Review list of probable causes.
   b. Correct compression problems.

STUDENT INFORMATION SHEET

WELDING

UNIT:	Introduction to Welding
TOPIC:	Introduction to Oxyacetylene Welding
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to identify welding equipment and safely set up, light, adjust, and operate oxyacetylene welding equipment properly.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to set up oxyacetylene equipment, light and adjust the welding torch, form a puddle, turn off the torch, and produce types of flames used in oxyacetylene welding.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with oxyacetylene welding will include science, oral and written communications, and application of mathematical principles.*

Oxyacetylene Welding

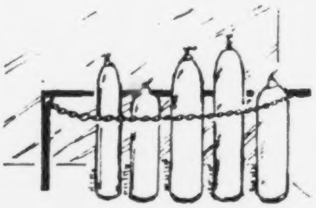
Oxyacetylene (sometimes called gas) welding joins metals by melting them together by the heat of a torch. The general process became possible shortly before 1900.

This type of welding is very useful when welding away from a shop is necessary, when welding thin materials, or when the amount of heat applied must be changed and controlled. Oxyacetylene welding is used in a large number of manufacturing, construction, and service industries.

Oxyacetylene welding is performed not only by welding specialists but workers in other jobs such as auto mechanics, plumbing, and farm equipment repair.

Oxyacetylene welding is one process of joining metals by fusion alone. In the oxyacetylene process, the metal is heated by the very hot flame of a gas-fed torch. The metal melts and flows together producing the weld. In most cases, more metal from a welding rod is melted into the joint, which adds strength to the welded metal.

Dangers are always present when gases are compressed, stored, transported, and used under high pressures. The welding gases, **oxygen** and **acetylene**, are delivered to the welder under pressure in steel cylinders. The cylinders are designed to be very safe and most accidents occur as a result of misuse by the welder.



Oxygen

Oxygen is always one of the products needed to produce a flame. It is a **colorless, odorless, tasteless** gas which is slightly heavier than air. When air combines with other gases to produce a flame, the flame has a low temperature and the burning rate is slow.

If pure oxygen is used in place of air, the burning is much faster and the temperature much hotter. For this reason, oxygen must never be allowed to come in contact with anything that will burn without proper controls and equipment. Oil in the regulators, hoses, or torches burns with explosive speed when mixed with pure oxygen. The use of oxygen to blow dust and dirt from work tables or from a welder's hair or clothing is very dangerous.

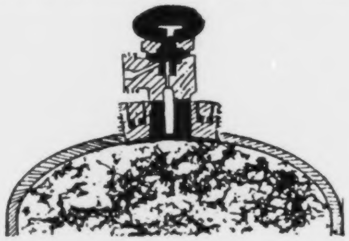
Most oxygen produced in the United States is made by first causing air to liquefy and then removing the pure oxygen. This oxygen is of such high quality that it can be used not only to produce the flame for welding and for flame cutting, but also for medical needs.

Acetylene

Acetylene gas is a chemical made up of carbon and hydrogen. When this gas is combined with oxygen, it can produce the hottest gas flame on earth. Acetylene is unstable and must be handled properly to avoid explosions.

Being unstable, free acetylene tries to separate when placed under a pressure higher than 15 pounds per square inch. This produces large amounts of heat, and high pressure develops so rapidly that an explosion may occur.

Acetylene gas must be dissolved in a liquid acetone in the cylinder so that it will not separate and can safely be used. Any attempt to compress acetylene in hoses, pipes, or cylinders in the free state at pressure higher than 15 pounds per square inch can only result in an explosion.



The **oxyacetylene flame** is the tool of fusion welding. The other welding equipment is made to control the flame, supply the gases in the correct amount and pressures, and provide an easy method of applying and controlling this flame. The flame must be of the proper size, shape, and condition to produce good results. A difference between the oxyacetylene flame and other types of tools is that this tool is not ready-made, and the welder must produce the proper flame each time the torch is lit.

Once an individual has learned how to adjust the flame, the individual's ability as a welder will increase with the amount of practice on the different types of joints in different metals. Oxyacetylene welding is the best form of welding to learn first because the individual can watch how metals melt and flow together at a controlled speed.

Safety and the Equipment

Cylinders should be fastened in an upright position to a wall or dolly so they cannot be knocked over.

Acetylene cylinders should **never** be laid on their side because the acetylene is a liquid and the acetone will be drawn out with the acetylene.

Stop welding when the torch is burning with a purple flame.

Note: *This shows that the acetone is being burned.*

Do not handle welding equipment with oily gloves, and do not oil the regulators.

Note: *Oil can explode when pressurized oxygen hits it.*

Remove dust and dirt from the valve openings by opening and quickly closing cylinder valves before attaching a regulator.

Loosen the adjusting screw on the regulator before opening the cylinder valve so that no damage will occur to the regulator.

Stand to one side of the regulator when opening the cylinder valve.

Open valves very slowly on cylinders.

Never use acetylene at pressures above 15 PSI because it is unstable and can easily explode.

Check every few days for leaks in hoses and fittings, using soapy water.

Remove gases from the lines one at a time before lighting the torch so that gases that may have mixed in lines will not ignite and cause a flashback.

Have safety clothing and protection in place before lighting the torch.

Always light the acetylene before opening the oxygen valve on the torch.

Make sure that no person or any material that will burn is in the direction of the flame when lighting and using the torch.

Do not use the oxygen in the torch to cool yourself; the oxygen can cause your clothing to burn very rapidly if your clothes catch fire.

Know how to use fire extinguishers in the shop.

Open the acetylene valve no more than one turn so that it may be shut off quickly in case of a fire.

Avoid welding materials that give off poisonous fumes.

Provide proper ventilation in welding areas.

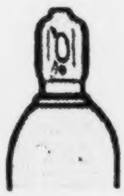
Close main cylinder valves when the oxyacetylene unit is not to be in use for long periods of time.

Turn off acetylene torch valve and then the oxygen torch valve when shutting down the welding unit.

Remove extra or empty cylinders from the welding area and building when possible.

Note: *Tag cylinders as empty.*

Place steel safety caps on all cylinders when moving or storing them.



Keep welding area neat and free from extra materials.

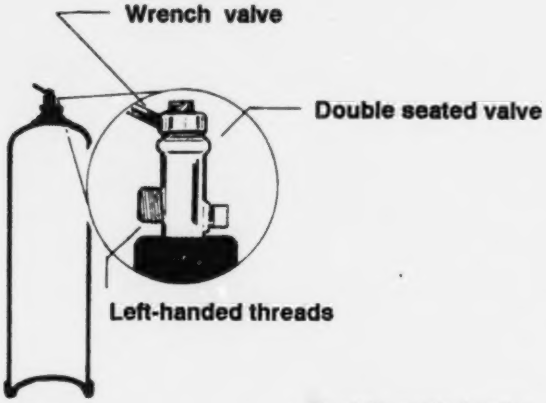
Do not handle hot metal with gloves; use pliers.

Use tight-fitting wrenches when installing or removing regulators.

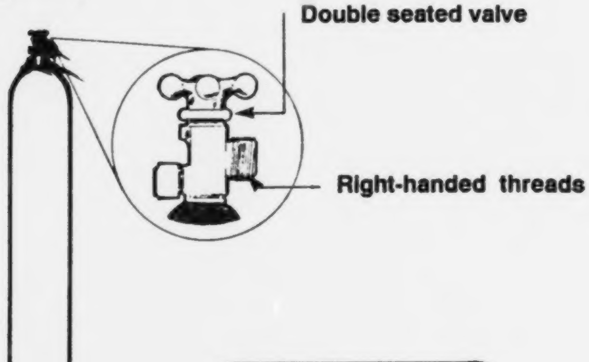
Oxyacetylene Welding Equipment

Cylinders

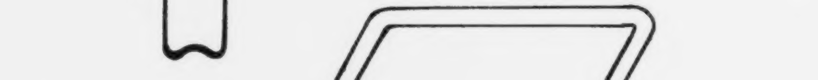
1. Acetylene


Wrench valve
Double seated valve
Left-handed threads

2. Oxygen

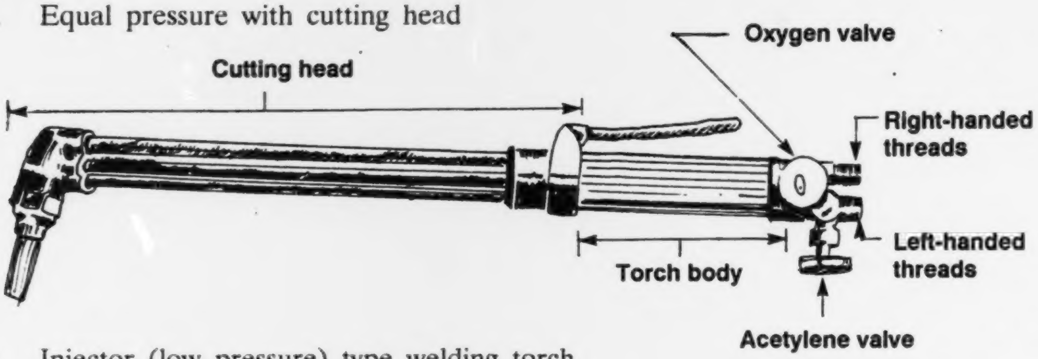

Double seated valve
Right-handed threads

Cart or dolly

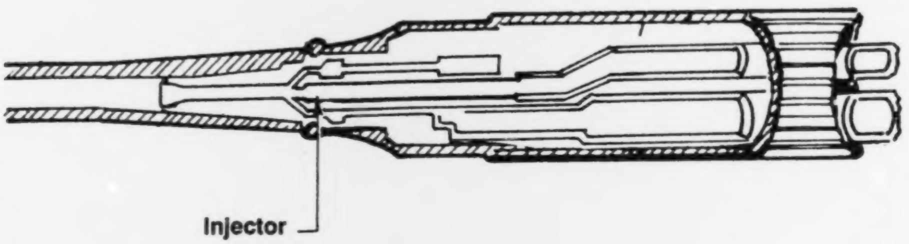

Torch and accessories tray
Safety chains
Rubber tires

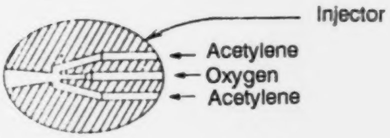
Types of torches

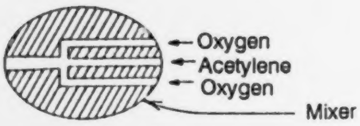
1. Equal pressure with cutting head


Oxygen valve
Cutting head
Right-handed threads
Left-handed threads
Torch body
Acetylene valve

2. Injector (low pressure) type welding torch

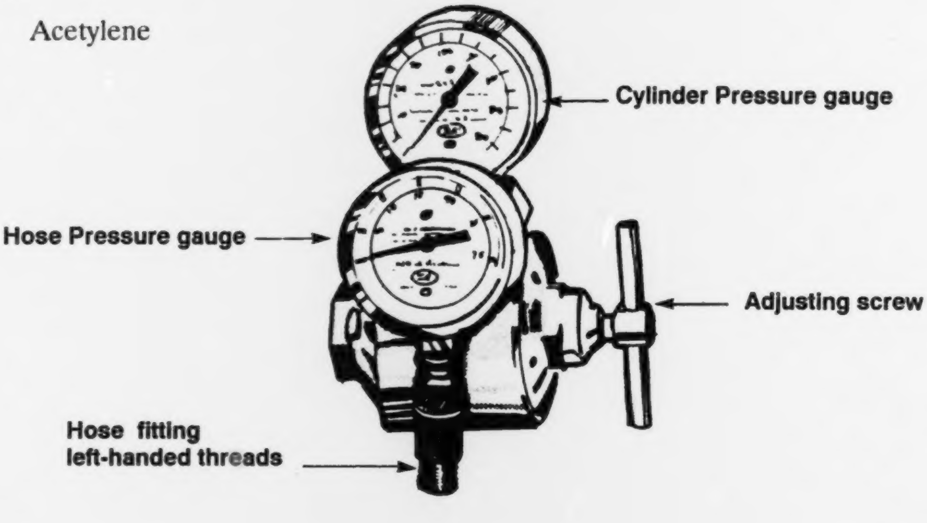



Injector
Acetylene
Oxygen
Acetylene

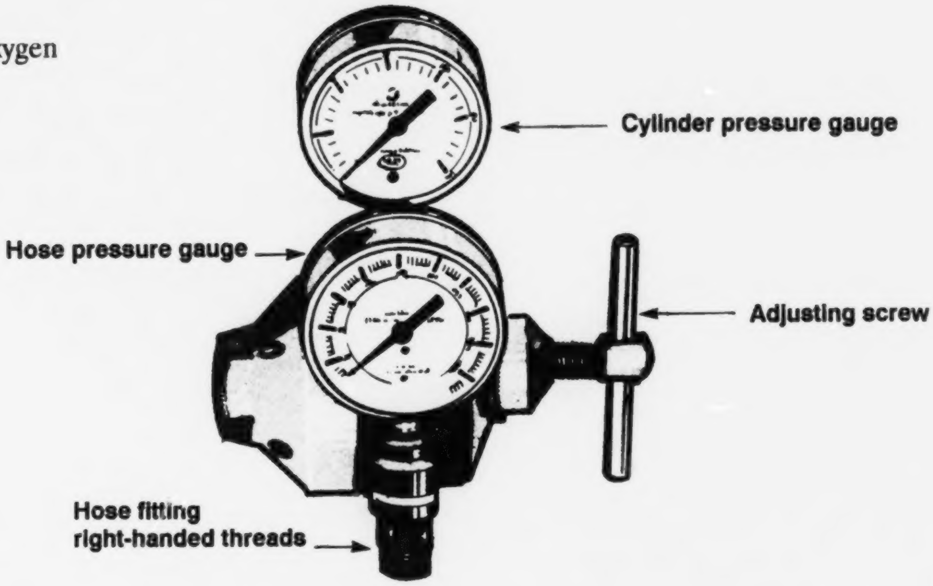

Oxygen
Acetylene
Oxygen
Mixer

Regulators

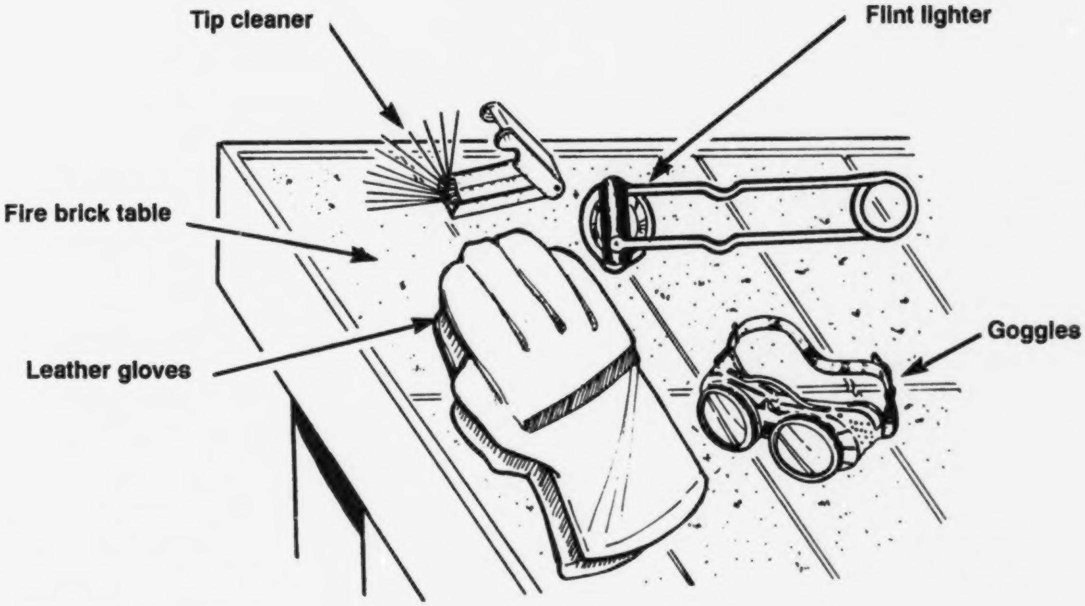
1. Acetylene


Cylinder Pressure gauge
Hose Pressure gauge
Adjusting screw
Hose fitting left-handed threads

2. Oxygen


Cylinder pressure gauge
Hose pressure gauge
Adjusting screw
Hose fitting
right-handed threads

Accessories


Tip cleaner
Flint lighter
Fire brick table
Leather gloves
Goggles

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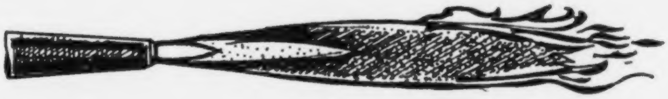
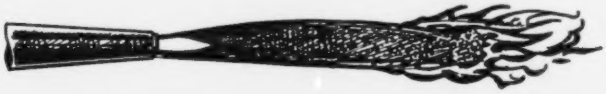
Types of Oxyacetylene Flames

Carburizing



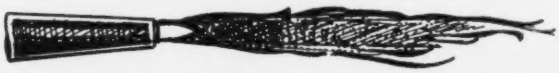
- Uses more acetylene than necessary
- Produces black smoke and a long yellow flame

Neutral



- Used for best welding results
- Uses equal amount of oxygen and acetylene
- Is recognized by a clear inner cone
- Produces a temperature of about 6,000 Fahrenheit

Oxidizing



- Uses more oxygen than necessary
- Inner cone is shorter than in neutral flame
- Inner cone appears to jump away from the tip of the torch
- Produces the hottest flame of the three
- Has a hissing sound

Terms and Definitions

Backfire is a momentary backing of the flame into the welding tip and usually accompanied by a loud pop.

Base metal is the metal to be welded, brazed or cut.

Flashback is a continued burning back of the flame into the tip, mixer or torch body and is accompanied by a loud hiss or squeal.

Fusion welding is the welding process that joins metals by heating them to a melting point and allows them to fuse or flow together and then cool.

Interpass heating is the application of heat to a base metal during a welding process.

Penetration is the distance from the original surface of the base metal to that depth at which fusion stops.

Postheating is heating after a welding operation to provide uniform cooling and stress relief.

Preheating is the heating prior to a welding or cutting operation.

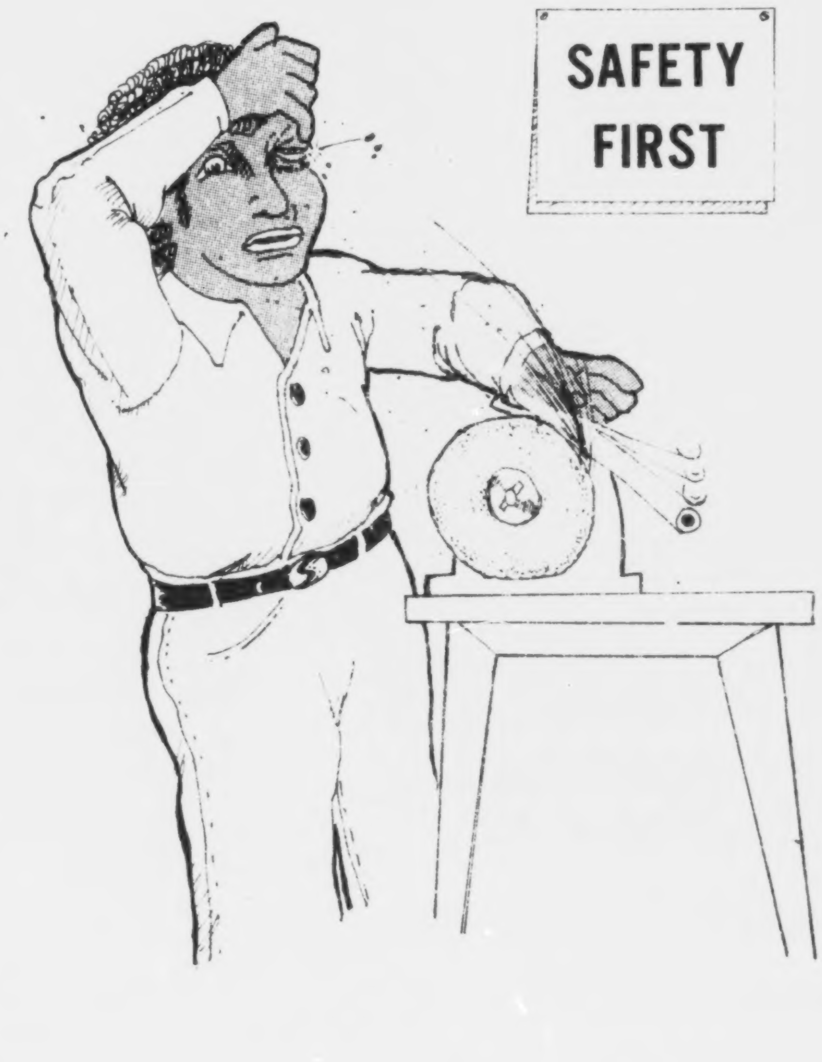
Stress relief is a process where base metals are heated to even temperature below the critical range, held at that temperature for a given time, and then uniformly cooled to avoid distortion, cracking or other stress-related problems.

Tack weld is a short weld used to hold the workpieces in place temporarily.

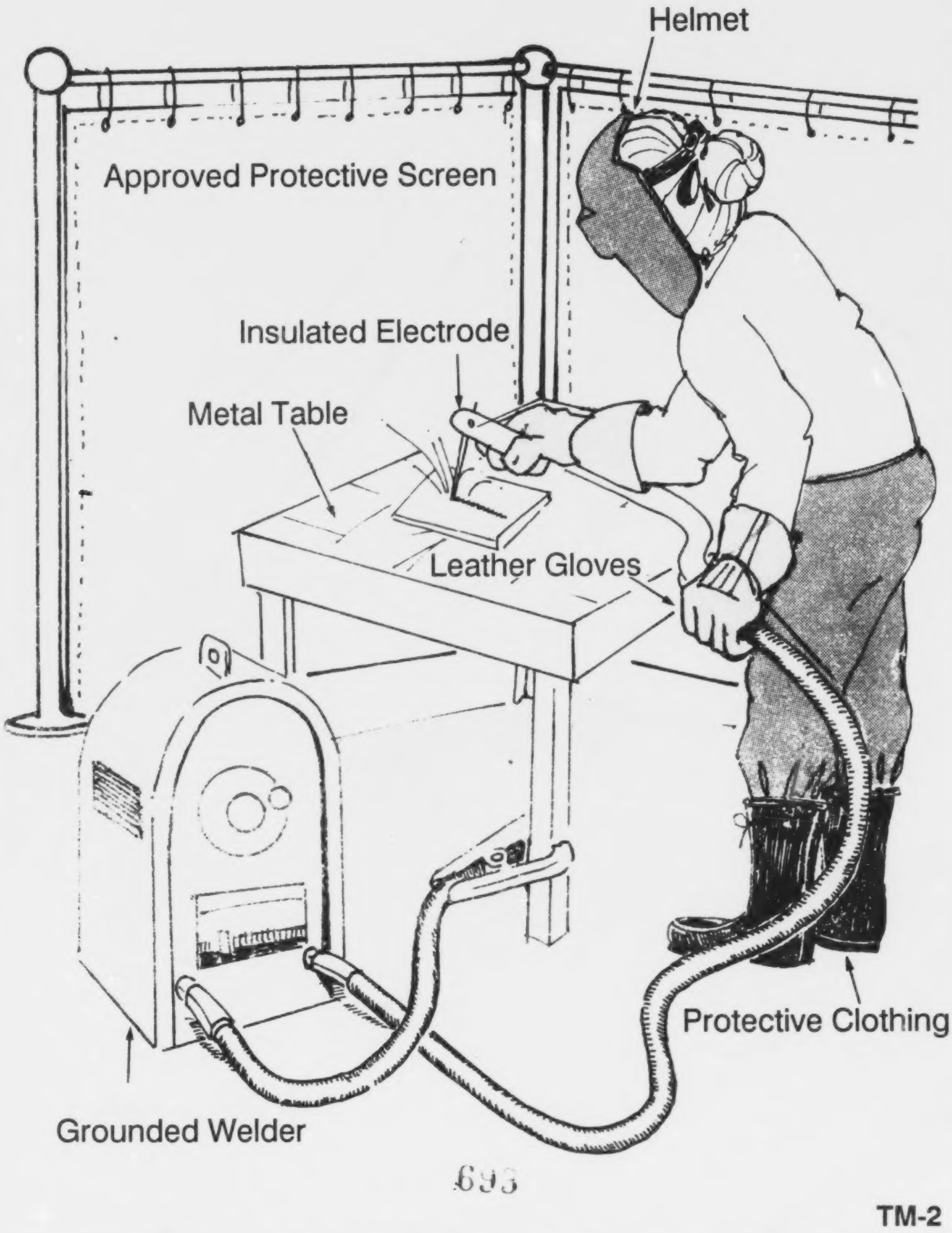
Temperature of neutral flame is 5900 degrees (Fahrenheit) which remains the same even as the flow of the gases is increased or decreased.

Tip orifice is the hole in the flame end of the welding tip.

Eye Protection Always Required When Grinding


SAFETY
FIRST

Protective Equipment


Helmet
Approved Protective Screen
Insulated Electrode
Metal Table
Leather Gloves
Protective Clothing
Grounded Welder

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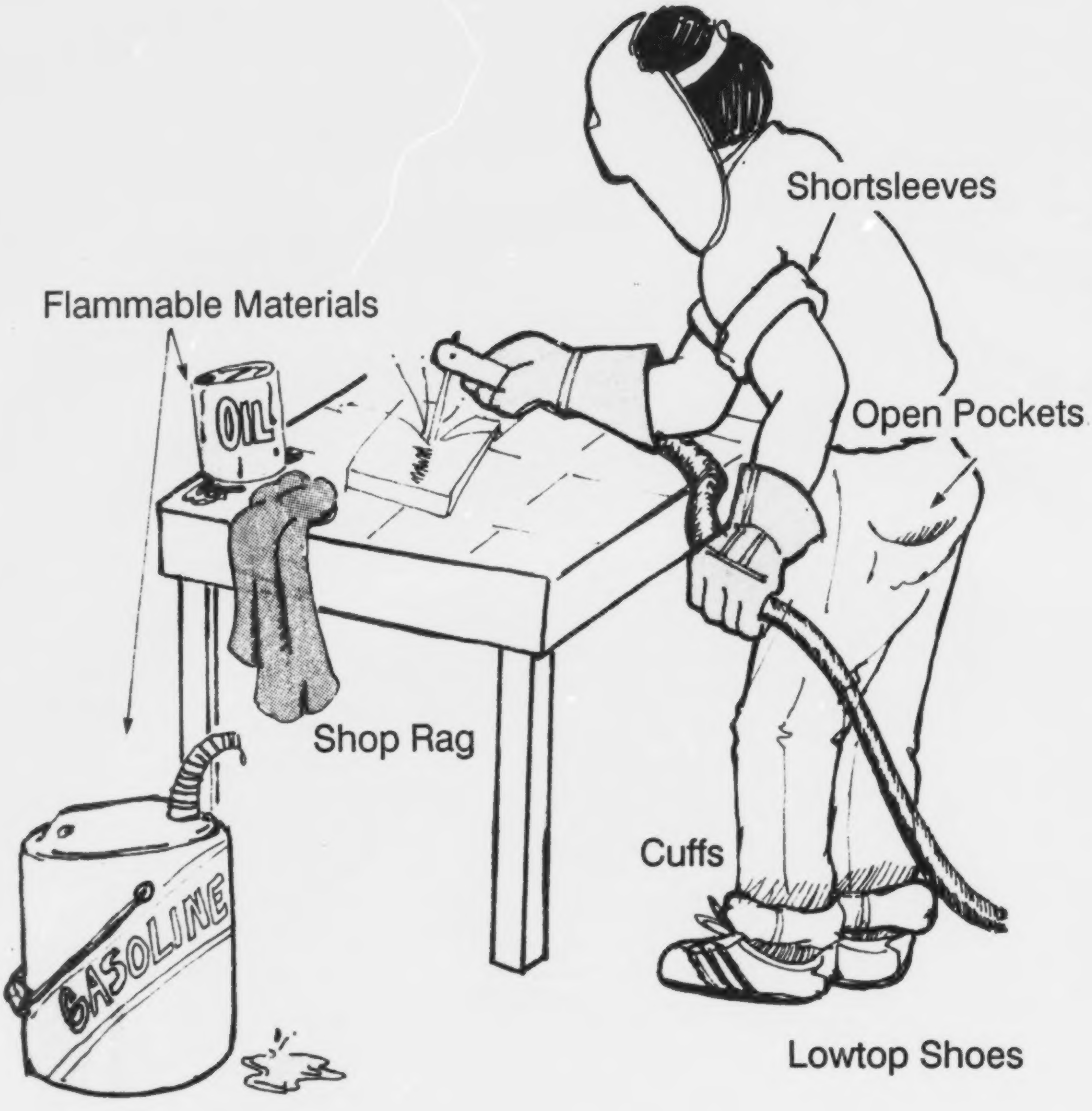
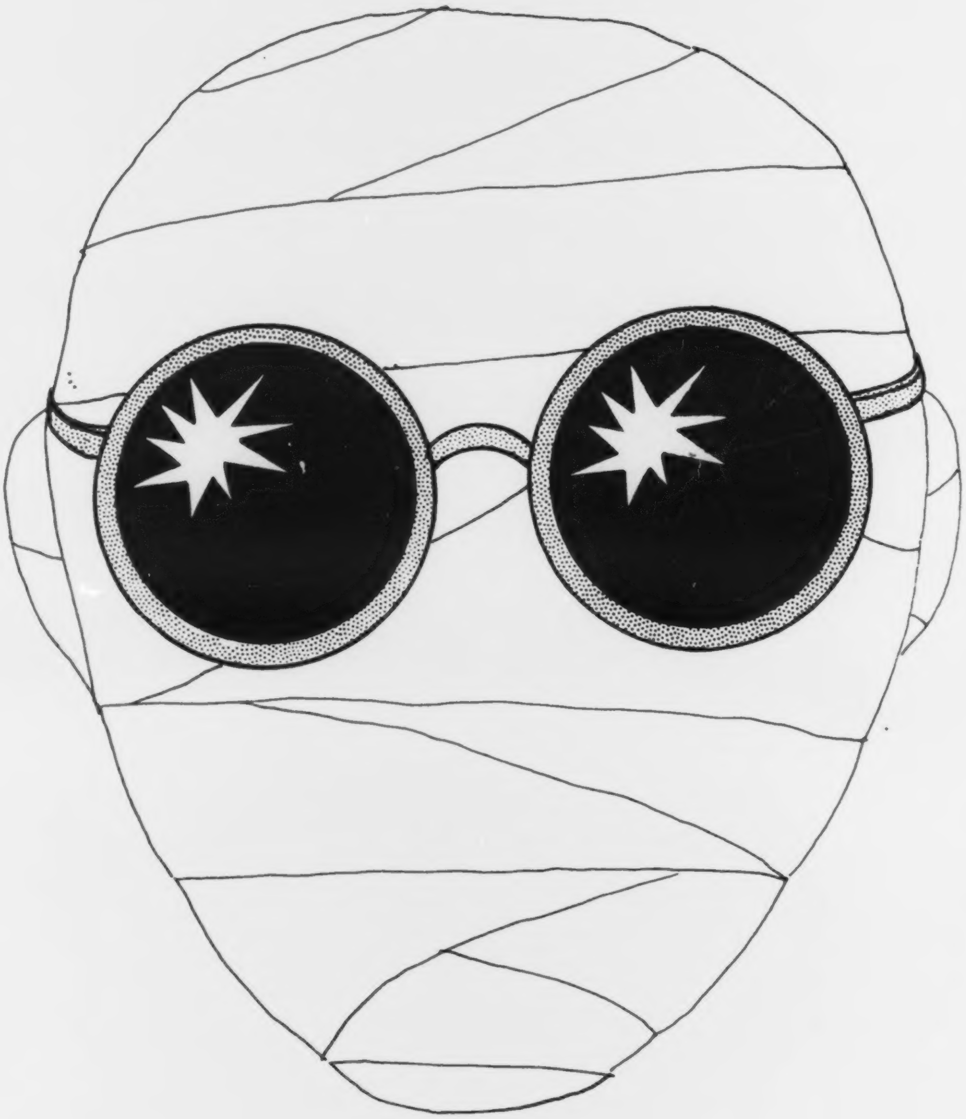
Common Unsafe Procedures


Shortsleeves
Flammable Materials
OIL
Open Pockets
Shop Rag
Cuffs
GASOLINE
Lowtop Shoes

Arc Welding Radiation Can Burn!



Always Use A Welding Helmet or Shield

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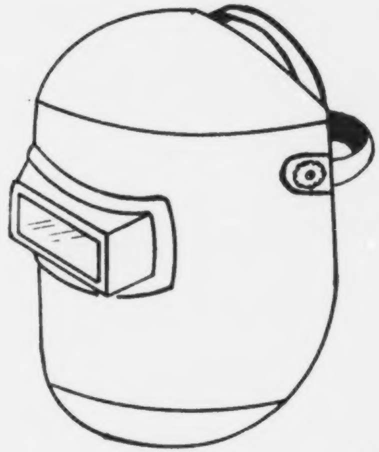
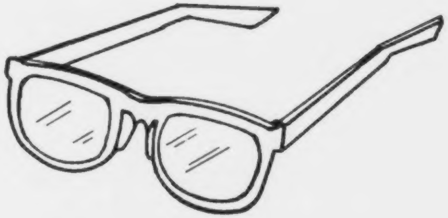
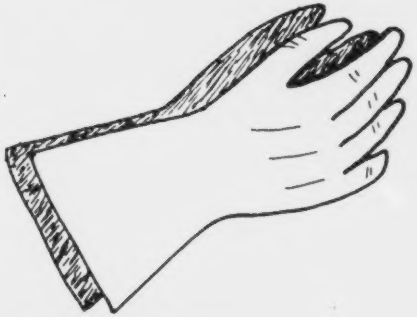
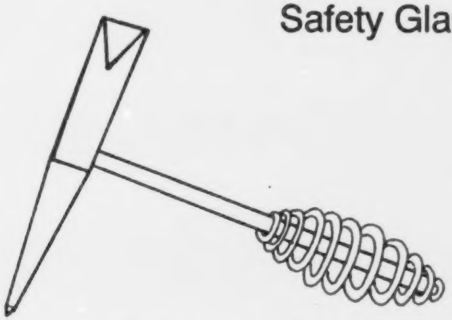
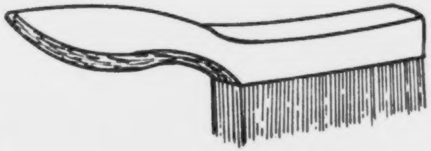
Welding Equipment

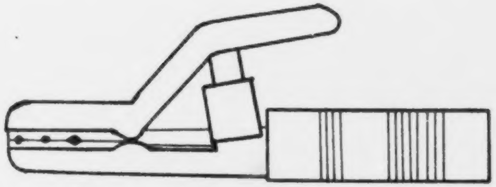

Helmet

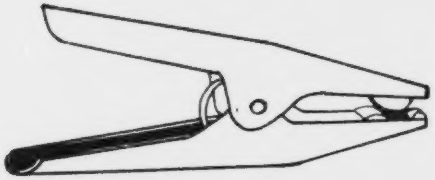

Safety Glasses

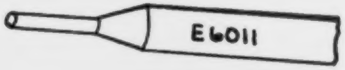

Leather Gloves


Chipping Hammer


Wire Brush


Electrode Holder

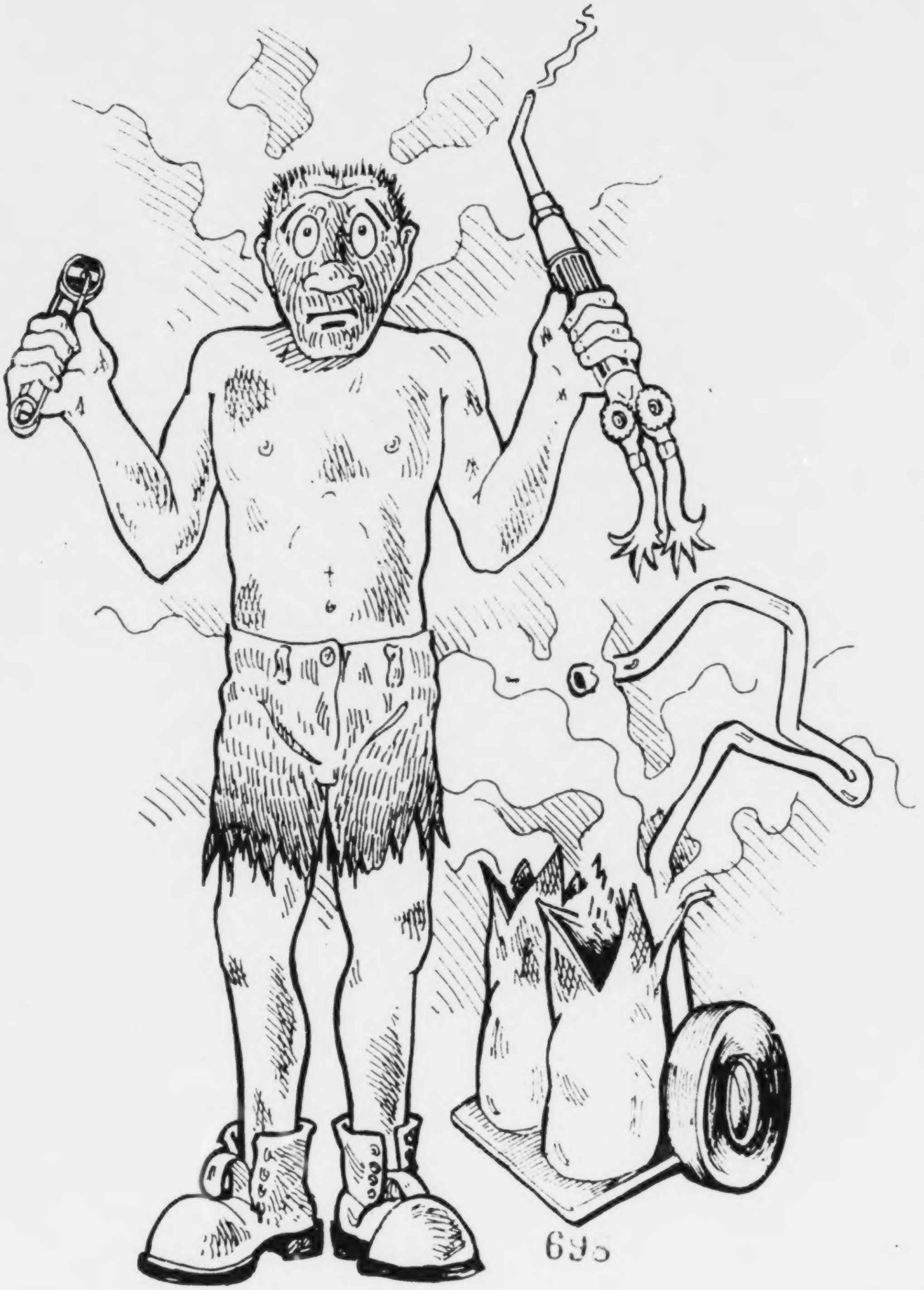

Ground Holder



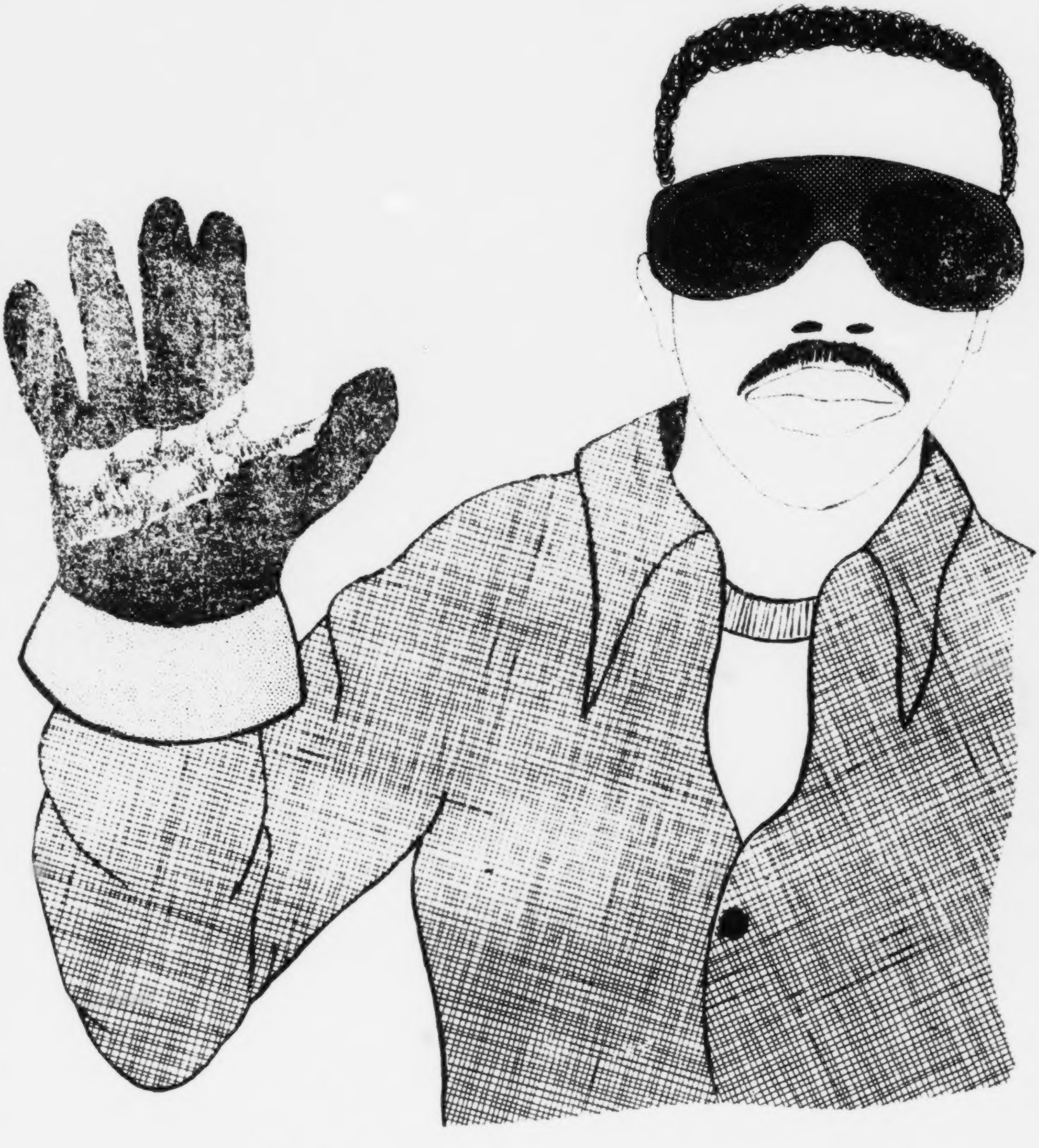
Electrode

TM-5

Look Before You Light



Don't Pick Up Hot Metal With Gloves—Use Pliers



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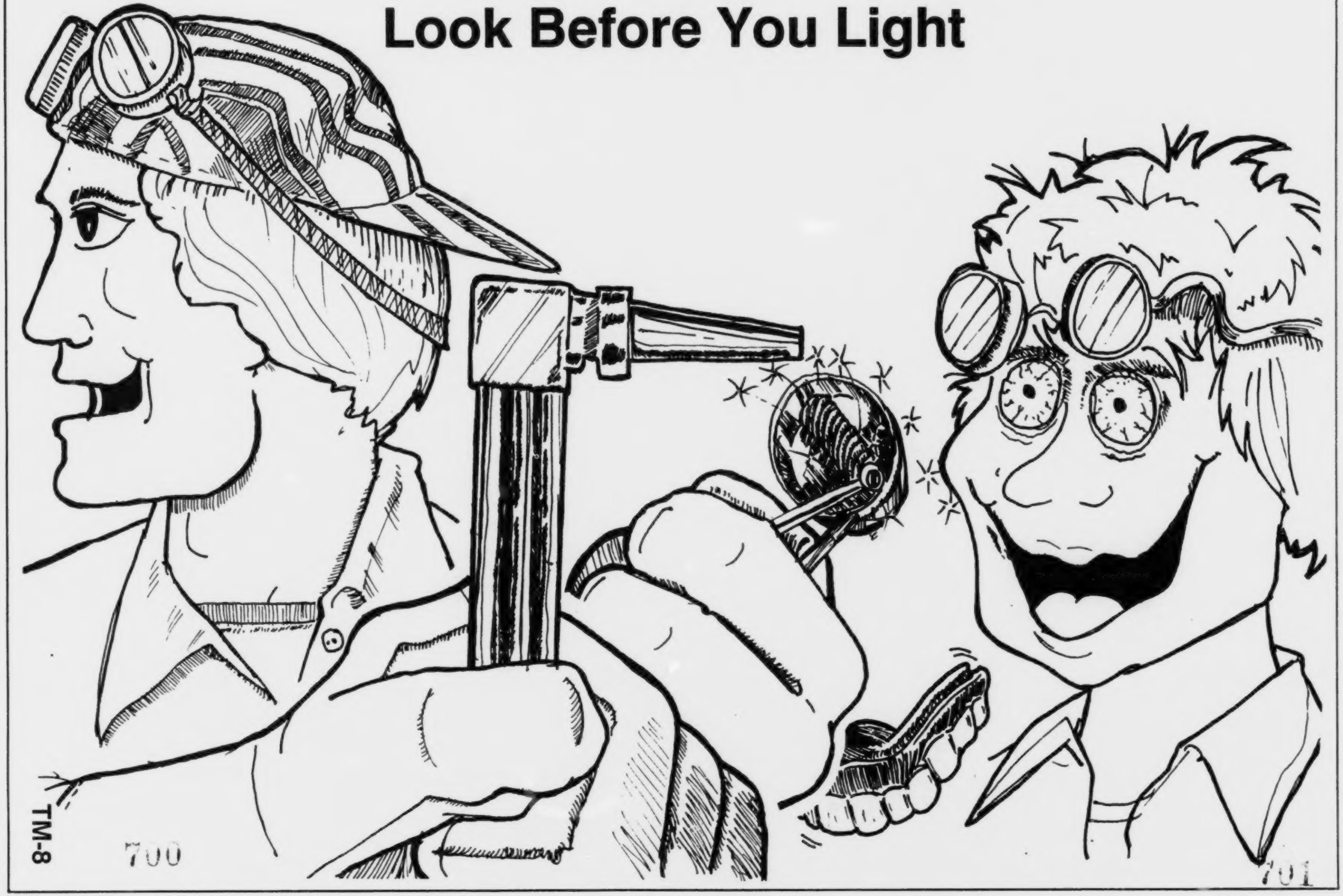
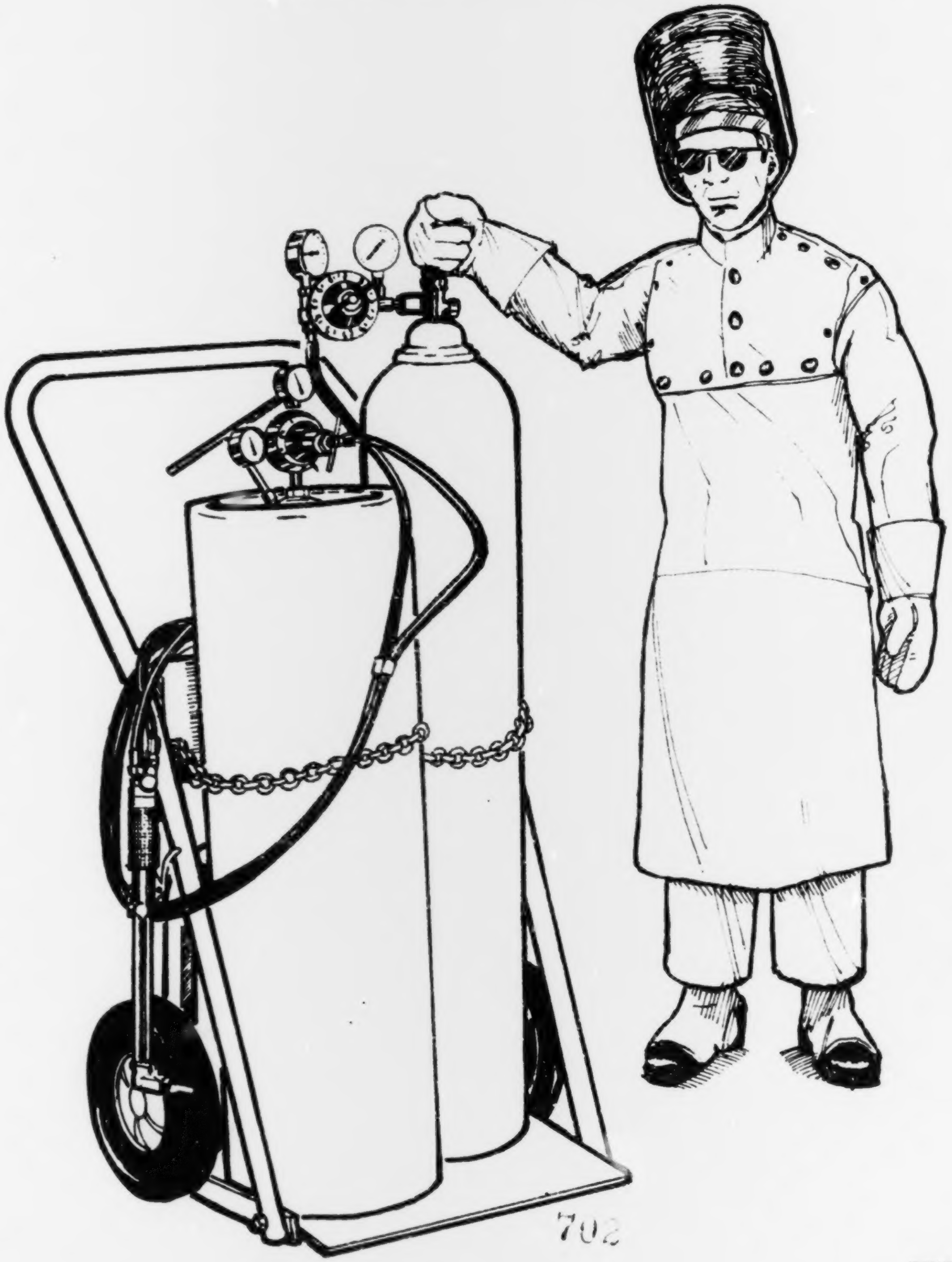
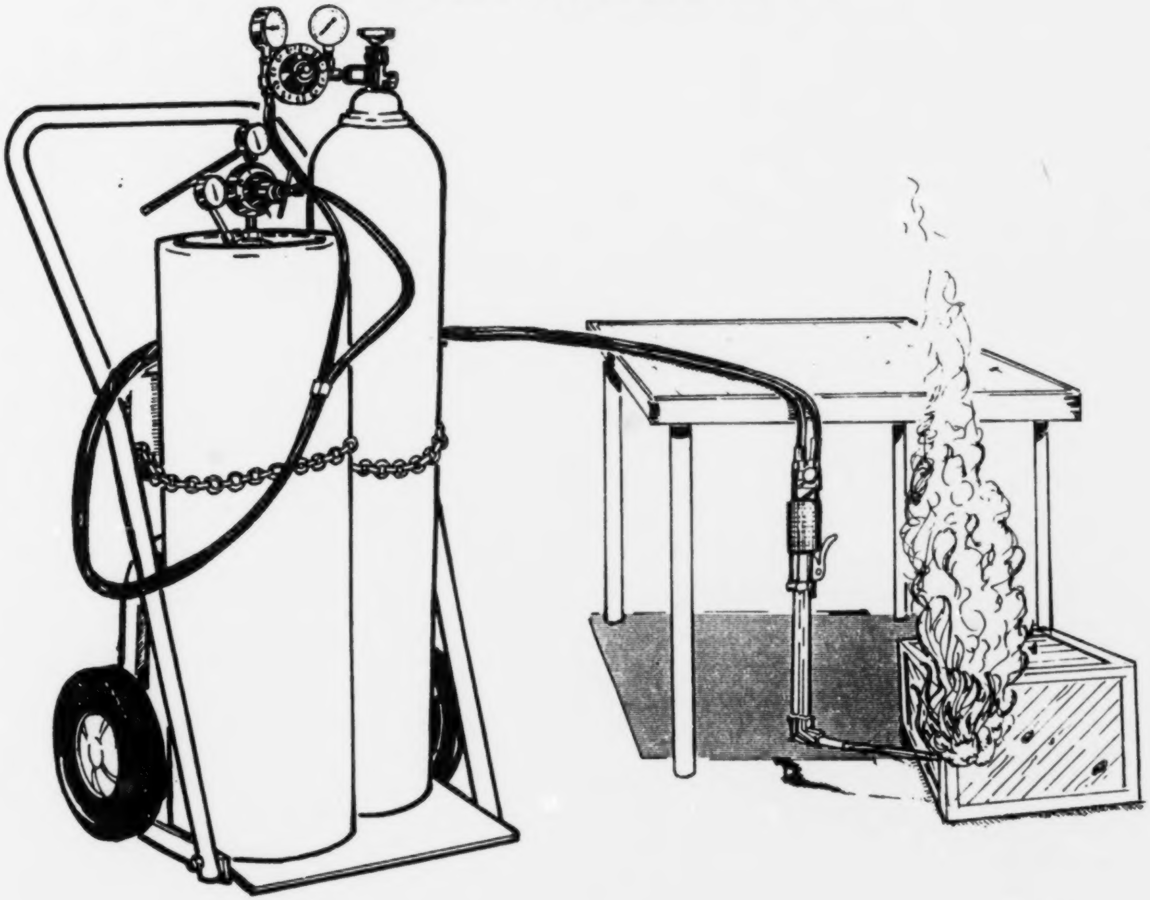
Look Before You Light



Stand To Side When Opening Cylinder Valves

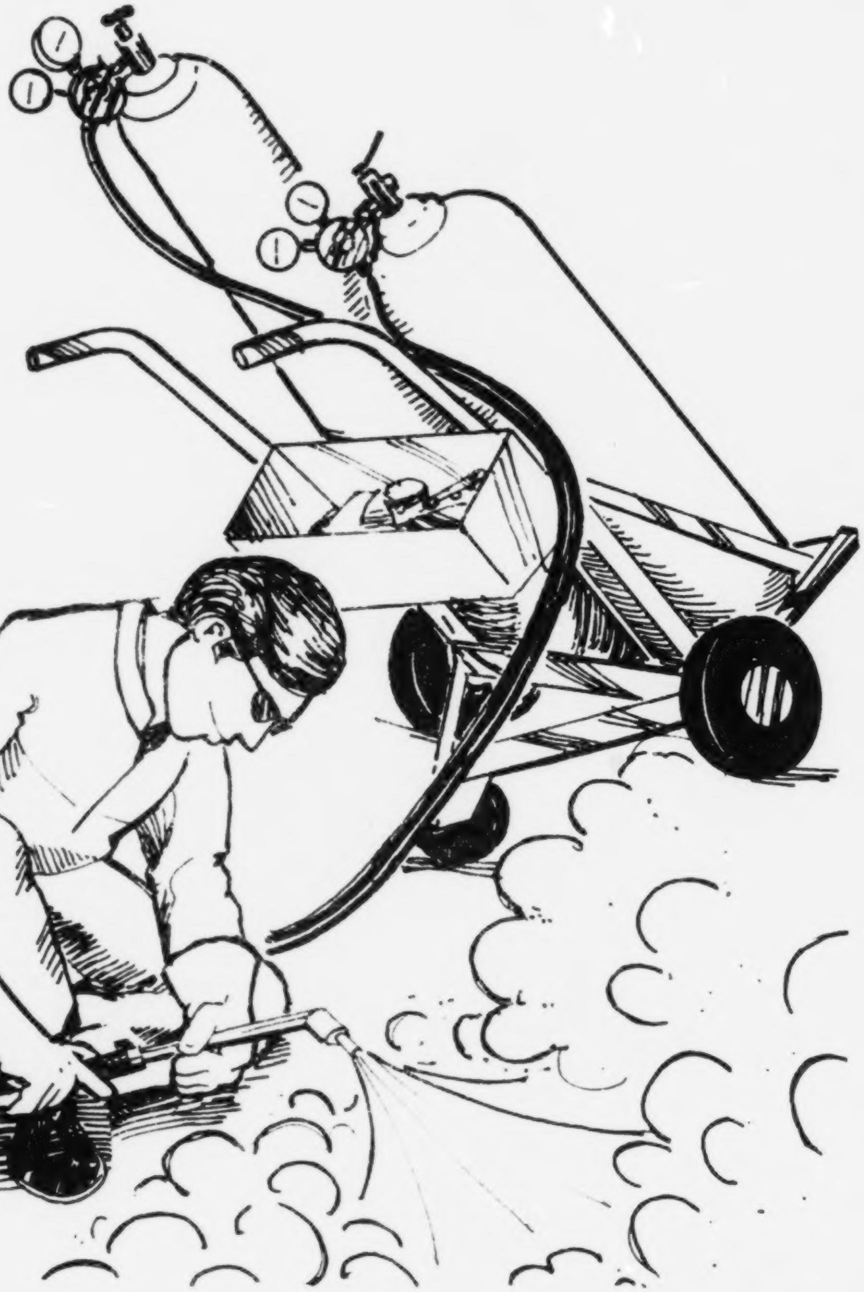


Don't Leave A Lighted Torch Unattended



TM-10

Blow Guns Blow Up



Don't Use Welding Gas To Blow Dust

TM-11

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ASSIGNMENT SHEET

WELDING

NAME ______________________________ **DATE** ________________

UNIT: Introduction to Welding

TOPIC: Introduction to Oxyacetylene Welding

DIRECTIONS: Read and answer the following questions in the space provided.

Fill in the blank with the word that will best complete the statement. Use words listed below.

acetylene
non-pressure
oxygen
melting
efficiency
flame
1900
higher
medical
explosive
fusion

1. Oxyacetylene welding joins metals by ____________ them together.
2. The process of oxyacetylene welding has been used since the year ____________.
3. Oxyacetylene welding is one basic process of joining metal by ____________ alone.
4. If pure oxygen is used, the burning temperature of the flame is much ____________ than when air alone is used.
5. Oxygen is not only used for welding but also is used for ________________ needs.
6. If free ________________ is placed under a pressure greater than 15 pounds per square inch, it may explode.
7. __________ is always one of the elements needed to produce a flame.

8. Oil in regulators, hoses, or torches will burn with ____________ speed when exposed to pure oxygen.

9. The torch flame must be of proper size, shape, and condition to operate with maximum ________________________.

10. The welder must produce the proper ____________ each time the torch is lighted.

11. Point out the correct safety rules by writing **True** or **False** for each of the following statements.

_______ a. Cylinders should be fastened to a wall or dolly in an upright position so they cannot be knocked over.

_______ b. Acetylene cylinders should never be laid on their sides because the acetylene is in the liquid acetone and the acetone will be drawn out with the acetylene.

_______ c. Stop welding when the torch is burning with a yellow flame as the acetone is being burned.

_______ d. Do not oil the regulators or handle welding equipment with oily gloves .

_______ e. Open cylinder valves for several minutes to remove dust and dirt before attaching a regulator.

_______ f. Loosen the adjusting screw on regulator before opening the cylinder valve so no damage to the regulator or injury to the operator will occur.

_______ g. Stand directly in front of the regulator when opening the cylinder valve so that you can see the regulator better.

_______ h. Open valves very slowly on cylinders.

_______ i. Never use acetylene at pressures above 15 PSI because it is very **unstable**.

_______ j. Check for leaks in hoses and fittings every 15 minutes with soapy water.

_______ k. Drain the oxygen and acetylene lines at the same time because it is quicker.

_______ l. Have safety clothing and protection in place before lighting the torch.

_______ m. Always light the acetylene before opening the oxygen valve on the torch.

_______ n. Make sure that no one or any material that will burn is in the direction of the flame when lighting and using the torch.

_______ o. Oxygen is a cooling gas and can be used to cool oneself on a hot day.

_______ p. Know how to use fire extinguishers in the shop.

_______ q. Open the acetylene cylinder valve several turns so that the acetylene gas will flow freely.

_______ r. Avoid welding on materials that give off fumes that are poison or that may explode.

_______ s. Ventilation in welding areas is not necessary because smoke rises.

_______ t. Close the main cylinder when the oxyacetylene unit is not in use for long periods of time.

_______ u. Turn off the oxygen torch valve fast when shutting down the welding unit.

_______ v. Leave empty cylinders in the welding area because you should move cylinders as little as possible.

_______ w. Place steel caps on all cylinders when moving or storing them.

_______ x. Keep welding area neat and free from extra materials.

_______ y. Avoid handling hot metal with gloves.

_______ z. Use loose-fitting wrenches when installing or removing regulators so the wrenches may be removed quickly.

12. Write the number of each part of the oxyacetylene welding equipment by its correct name.

_______ a. Oxygen cylinder

_______ b. Acetylene cylinder

_______ c. Cylinder valves

_______ d. Winged adjusting nut

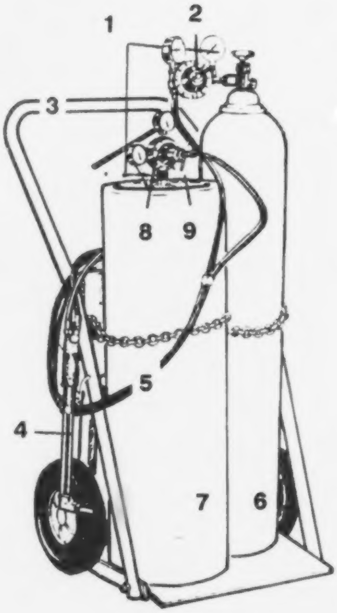
_______ e. Cart

_______ f. Oxygen regulator

_______ g. Acetylene regulator

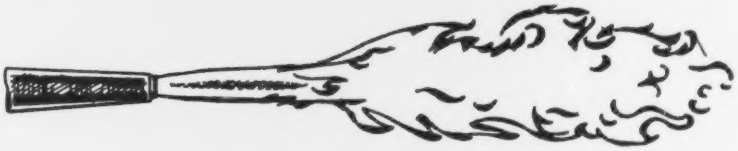
_______ h. Torch body

_______ i. Hoses

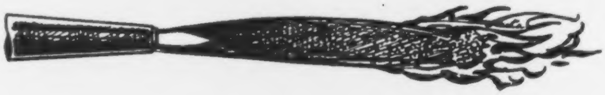


13. Write the correct name of each of the oxyacetylene welding flames in the correct blank.

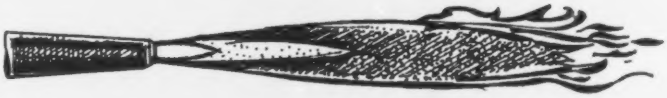
Neutral	Acetylene burning in air
Oxidizing	Carburizing



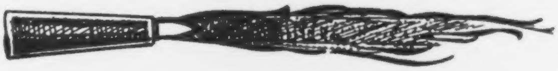
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

14. Match the parts of a welding torch with their functions.

____a. The basic body of the torch that contains valves to control the flow of oxygen and acetylene.	1. Welding head or tip
____b. The welding torch component that contains mixer or injector, and the mixing throat.	2. Torch handle

15. The ____________________ oxyacetylene flame is the best for welding.

JOB SHEET
WELDING

NAME ______________________ **DATE** ______________

UNIT: Introduction to Welding

TOPIC: Set up Oxyacetylene Equipment for Welding

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to set up oxyacetylene equipment for welding correctly.

TOOLS AND EQUIPMENT:

Complete oxyacetylene welding unit
Gloves
Lighter
Goggles
Coveralls
Soapy water and brush
Proper open end wrench for brass fittings
Oxygen and acetylene cylinders
Dolly or cart

GENERAL INSTRUCTIONS: Follow procedures to set up oxyacetylene equipment for welding properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Set-up

1. Place cylinders in dolly.

   Note: *Fasten cylinders to a wall or bench when a dolly is not available.*

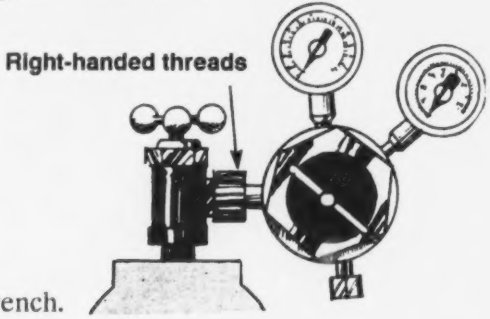
2. Remove safety caps from both cylinders.

3. Quickly open and close each valve to clean the opening for the fittings.

CAUTION: Stand to one side of the valve openings.

4. Attach the oxygen regulator to the oxygen cylinder.

Note: *This nut is smooth and has right-hand threads.*



5. Tighten the nut **securely** with the wrench.

6. Open the oxygen cylinder valve **very slowly** until the high pressure gauge has stopped moving.

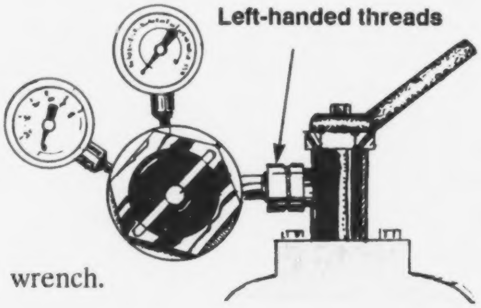
Note: *Opening the cylinder valve too fast may damage the regulator.*

CAUTION: Stand to the side of the regulator.

7. Open the valve all the way.

8. Attach the acetylene regulator to the acetylene cylinder.

Note: *This nut has a groove cut around it and has left-hand threads.*



9. Tighten the nut securely with a wrench.

10. Open the acetylene cylinder valve slowly for one quarter turn.

CAUTION: Stand to the side of the regulator.

Note: *If the cylinder does not have a valve wheel, an acetylene wrench must be used.*

11. Attach the acetylene hose to the acetylene regulator.

Note: *The acetylene hose is red, and the fitting has left-hand threads.*

12. Tighten the winged adjusting screw enough to allow a small amount of acetylene to flow through the hose, and then loosen it.

13. Attach the oxygen hose to the oxygen regulator.

    Note: *The oxygen hose is green and the fitting has right-hand threads.*

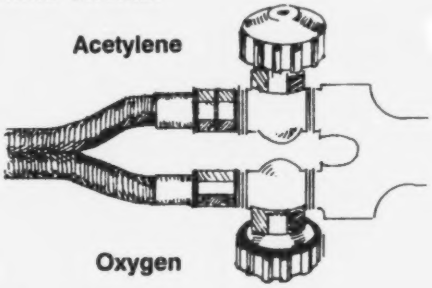
14. Screw the **winged** adjusting screw in enough to allow a small amount of oxygen to flow through the hose, and then back the screw out.

15. Connect the oxygen hose to the torch valve marked **oxygen**.

    Note: *The hose fitting has right-hand threads.*

16. Connect the acetylene hose to the torch valve marked gas.

    Note: *The hose fitting has left-hand threads.*



17. Connect a No. 1 heating tip to the torch body.

    Note: *Hand-tighten torch tips, make sure "O" ring is in good condition on the welding tip.*

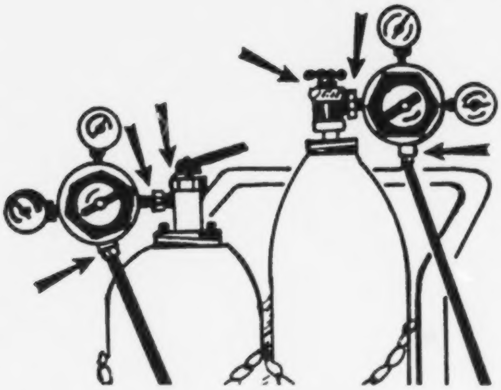
18. Close both torch valves.

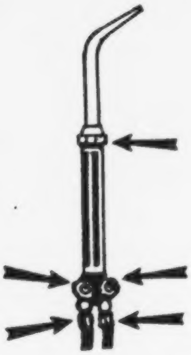
19. Adjust the winged adjusting screw on the oxygen regulator until the low pressure gauge reaches 3 to 5 pounds pressure.

20. Adjust the winged adjusting screw on the acetylene regulator until the low pressure gauge reaches 3 to 5 pounds pressure.

Leak test

1. Check all connections for leaks by brushing soapy water on all fittings and connections.





Leak testing locations

2. Tighten any leaking connections.

Shut-down

1. Close both cylinder valves.
2. Open the acetylene torch valve until the acetylene gauges reach zero and then close the valve.
3. Open the oxygen torch valve until the oxygen gauges reach zero and then close the valve.
4. Back out both winged adjusting screws on the regulators until they are loose.
5. Roll up hoses.
6. Place torch and welding dolly in a safe place.

IV-1-JS-2

JOB SHEET

WELDING

NAME ______________________ **DATE** ______________

UNIT: Introduction to Welding

TOPIC: Turn on, Light, and Adjust the Welding Torch, Form a Weld Puddle, and Turn off the Torch

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to turn on, light, and adjust the welding torch, form a weld puddle, and turn off the torch properly.

TOOLS AND EQUIPMENT:

Complete oxyacetylene welding unit
Gloves
Lighter
Goggles
Coveralls
Pliers
Welding plate

GENERAL INSTRUCTIONS: Follow procedures to turn on, light, and adjust the welding torch, form a weld puddle, and turn off the torch properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Opening and lighting the oxyacetylene welding unit

1. Check cylinder, regulator, and torch valves to make sure they are closed. Make sure wing adjuster is screwed all the way out.

2. Put on safety goggles, gloves, and coveralls.

3. Slowly open acetylene cylinder valve one turn.

4. Regulate the winged adjusting screw until the low pressure gauge reaches 5 PSI.

5. Slowly open oxygen cylinder valve until pressure has stopped climbing on the high pressure gauge, and then open the valve all the way.

6. Regulate the winged adjusting screw until the low pressure oxygen gauge reaches 5 PSI.

7. Using the flint lighter, light the torch by opening the acetylene torch valve 1/4 turn and striking the lighter in front of the tip.

8. Adjust acetylene valve until torch nearly quits smoking.

9. Open torch oxygen valve slowly until a neutral flame has been reached.

   Note: *There should be a clear inner cone in the flame.*

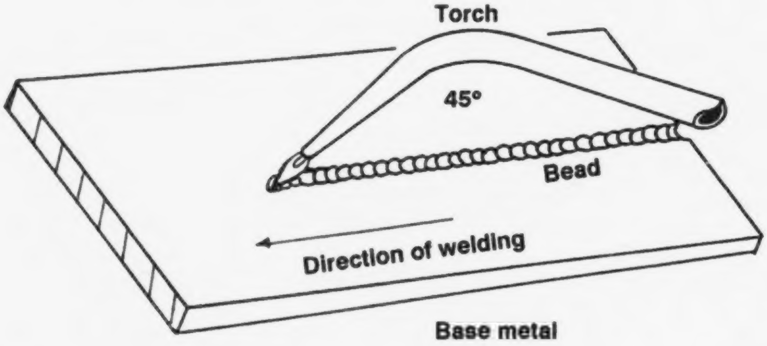
Forming a weld puddle

1. With goggles and gloves in place, hold torch 1/4 of an inch above the welding plate on the fire brick.

2. Hold in position until the metal under the flame becomes molten and then very slowly travel down the metal in a small 1/4-of-an-inch circling pattern.

3. Watch for an even weld pattern behind the weld puddle.

   Note: *A hole might appear if travel is too slow.*



4. After completing a weld puddle, close the acetylene torch valve.

5. Close the oxygen torch valve.

6. Place torch on table.

   Note: *Make sure not to lay torch on hoses or a hot area.*

Shutting down the oxyacetylene welding unit

1. With both torch valves closed, shut the acetylene cylinder valve.
2. Open torch acetylene valve until both gauges have reached 0 PSI.
3. Close torch acetylene valve.
4. Back the winged adjusting screw out until the tension on the regulator is released.
5. Close the oxygen cylinder valve.
6. Open the torch oxygen valve until both gauges reach 0 PSI.
7. Close oxygen torch valve.
8. Back the winged adjusting screw out until the tension on the oxygen regulator is released.
9. Roll up hoses on the welding cart or dolly and place torch where it will not get knocked to the floor.
10. Clean work area and turn in tools.

JOB SHEET

WELDING

NAME ________________________________ **DATE** ____________________

UNIT: Introduction to Welding

TOPIC: Adjust Torch for Welding

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to adjust torch for welding correctly.

TOOLS AND EQUIPMENT:

- Complete oxyacetylene welding unit
- Gloves
- Lighter
- Goggles
- Coveralls
- Pliers

GENERAL INSTRUCTIONS: Follow procedures to adjust the torch for welding properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Opening and lighting the oxyacetylene welding unit

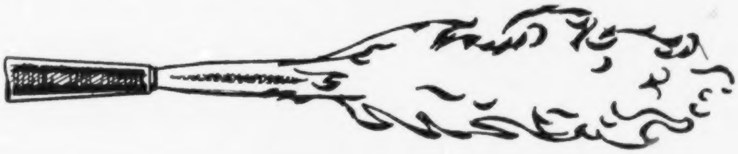
1. Check cylinder, regulator, and torch valves to make sure they are closed.
2. Put on safety goggles, gloves, and coveralls.
3. Slowly open acetylene cylinder valve one turn.
4. Tighten the winged adjusting screw until the low pressure gauge reaches 3 to 5 PSI.

5. Slowly open oxygen cylinder valve until the pointer has stopped moving on the high pressure gauge, and then open the valve all the way.

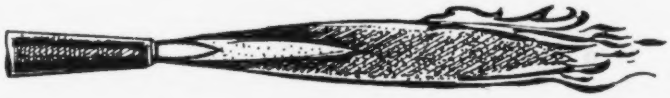
6. Tighten the winged adjusting screw until the low pressure oxygen gauge reaches 3 to 5 PSI.

7. Using the flint lighter, light the torch by opening the acetylene torch valve one-half turn and striking the lighter in front of the tip.

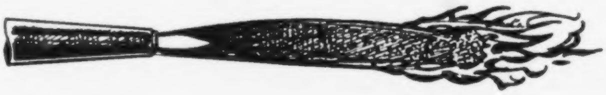
8. Open the acetylene valve until very little smoke can be seen.



9. Open oxygen valve slowly until a carburizing flame is produced.

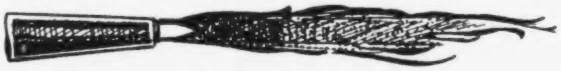


10. Keep opening the oxygen valve and watch the carburizing flame change into a neutral flame.



Note: *A proper neutral flame not only provides the proper heat required for welding but also provides a safe working condition. If the pressures in both oxygen and acetylene lines are equal, the gases will not back into one hose or the other to cause an explosive mixture.*

11. Keep opening the oxygen valve and watch the neutral flame change slightly. This is an oxidizing flame.



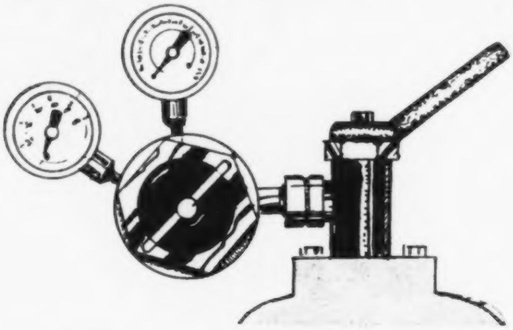
Note: *Notice the inner cone gets shorter and has a more pointed tip.*

12. Close the acetylene valve on the torch.
13. Close the oxygen valve on the torch.
14. Place torch on table.

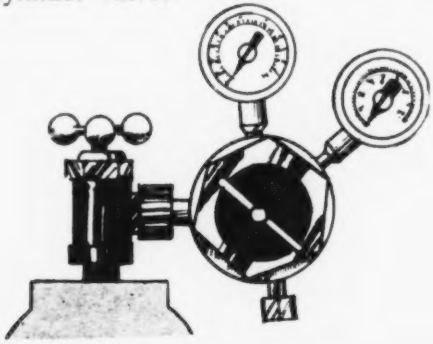
    Note: *Do not lay torch on hoses or a hot area.*

Shutting down the oxyacetylene welding unit

1. With both torch valves closed, **close** the acetylene cylinder valve.



2. Open torch acetylene valve until both gauges have reached 0 pressure.
3. Close torch acetylene valve.
4. Back the winged adjusting valve screw out on the oxygen regulator until it is loose.
5. Close the oxygen cylinder valve.



6. Open the torch oxygen valve until both gauges reach 0 pressure.
7. Close oxygen torch valve.
8. Back the winged adjusting screw out on the oxygen regulator until it is loose.

9. Practice this procedure until the entire operation can be performed easily.
10. Ask instructor to check you out on the light-up and shut-down of the welding rig.
11. Roll up hoses.
12. Place torch and welding dolly in a safe place.
13. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Welding

TOPIC: Make Weld Puddles with Different Torch Settings

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make weld puddles with different torch settings correctly.

TOOLS AND EQUIPMENT:

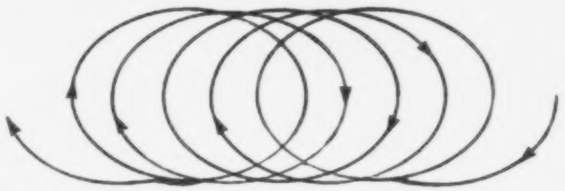
Welding tip for welding 1/16-in. metal
Scrap 1/16-in. metal
Protective clothing
Ball peen hammer and anvil
Vise
Cooling vat
Goggles

GENERAL INSTRUCTIONS: Follow procedures to make weld puddles with different torch settings properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Lighting the Torch

1. Light the torch and adjust to a neutral flame.
2. Run a bead by making small circles with a clockwise motion.



3. Continue to run beads until the beads are even and easily made.

Changing the torch flames

1. Run a bead on another plate, using a neutral flame.
2. Adjust torch to carburizing flame, and run a bead parallel to the first about ½-in. from it.

   Note: *The metal should give off sparks.*

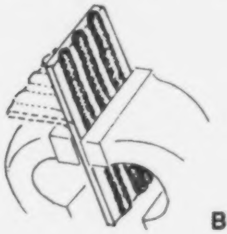
3. Adjust torch to an oxidizing flame and run a third bead parallel about ½-in. from the previous bead.

   Note: *The puddle blows away and the bead is much narrower than either of the others.*

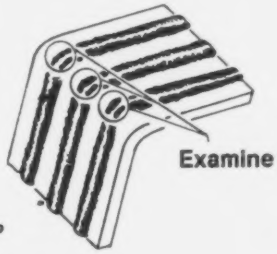
Testing

1. Cool the metal with cooling vat and place in vise. Bend the plate 90 degrees with the welds outward.

   Note: *The carburized bead has cracked and most of the oxidized material has fallen from the oxidized bead.*



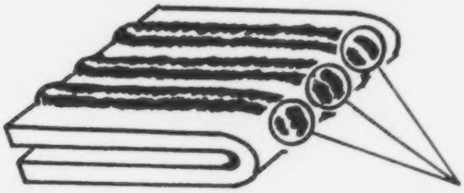
Bend test weld at 90°



Examine the three beads

2. Hammer the test plate on an anvil until it is bent flat.

   Note: *The carburized and oxidized beads have cracked and the neutral bead has bent as much as the original material with no failure.*



Examine the three beads

3. Turn finished plate in to the instructor.
4. Roll up hoses.
5. Place torch and welding dolly in a secure place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Welding

TOPIC: Lay Beads on Flat Plate with no Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a bead on a flat plate with no filler rod correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Welding gloves
Welding goggles
Pliers
Spark lighter
Flat plate steel workpiece selected by instructor.

GENERAL INSTRUCTIONS: Follow procedures to lay a bead with no filler rod properly.

PROCEDURES AND/OR TASKS: **Note:** *Use proper safety precautions.*

1. Be sure work area is clear of flammable materials and well ventilated. Secure workpiece.
2. Check thickness of workpiece. Select proper tip and secure it to welding torch.
3. Determine required regulator pressure. Set up and purge regulators and lines.
4. Put on gloves and goggles.
5. Light torch and adjust to a neutral flame according to safety standards.

6. Hold the torch in either hand and use forehand welding technique to complete this job sheet. **For a right-handed welder, the forehand technique travels from right to left, and for the left-handed welder, the forehand technique travels from left to right.**

7. Move the torch down until the inner cone of the flame is about ⅛-in. from the surface of the metal, hold it there until a small pool of molten metal forms.

8. Move back and forth in a series of short arcs or semi-circles while you advance the puddle as steadily as possible across the plate.

9. Keep the puddle oval-shaped and the bead as straight as possible as you continue to form the bead.

   Note: *A thin bead indicates welding speed is too fast, and a large bead indicates welding speed is too slow or tip is too close to workpiece.*

10. To compensate for heat buildup, after you have finished the first two-thirds of the weld, increase your welding speed slightly as the weld puddle indicates.

11. Before reaching the end of the weld, stop so molten metal will not drip off end of plate.

12. Leave about ½-in. between welds and start a second weld below the beginning point of the first weld.

13. Slightly increase welding speed as you finish the second weld to compensate for heat buildup in the plate.

14. Finish the second weld and continue making more welds ½-in. apart and parallel with welds one and two.

15. Observe puddles in relation to torch movement at all times and practice making the slight adjustments in welding speed as required.

16. Complete the final weld, shut off the torch, and shut down the equipment according to safety standards.

17. Have your instructor check work.

18. Cool and place all welded scrap material in a proper container and clean area as required.

19. Check tools and materials and place in proper area.

IV-1-JS-6

JOB SHEET
WELDING

NAME ______________________________ **DATE** __________________

UNIT: Introduction to Welding

TOPIC: Lay Beads on Flat Plate with a Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay beads on flat plate with a filler rod correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Welding gloves
Welding goggles
Pliers
Spark lighter

Flat plate steel workpiece selected by instructor
Mild steel rod as selected by instructor

GENERAL INSTRUCTIONS: Follow procedures to lay a bead on a flat plate with a filler rod properly.

PROCEDURES AND/OR TASKS: **Note:** *Use proper safety precautions.*

1. Be sure work area is free of flammable materials and well ventilated.
2. Secure workpiece.
3. Check thickness of workpiece. Select proper tip and secure it to welding torch.
4. Determine regulator pressure as required. Set up and purge regulators and lines.
5. Put on gloves and goggles.
6. Light torch and adjust to neutral flame according to safety standards.

7. Place filler rod so that half is off the work table, hold the free end of the rod, then heat the rod at the midway point until it melts in two. This will make the rod easier to hold.

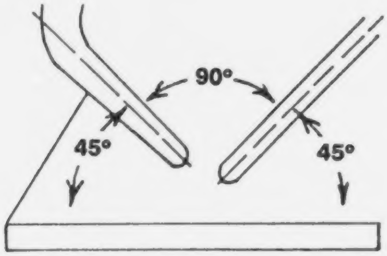
8. Hold the torch in one hand and the filler rod with the other hand; Use the forehand welding technique to complete this job sheet.

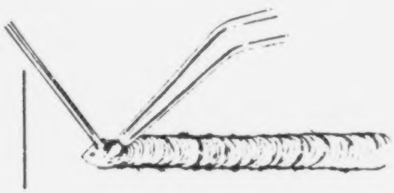
9. Move the torch down until the inner cone of the flame is ⅛-in. from the surface of the metal and hold it there until a small pool of molten metal forms, then begin a circular motion with the torch.

10. Move the rod into the center of the puddle at the point of the inner cone, and let a drop or two of molten metal fill the puddle.

11. Withdraw the rod about ½-in. to ¾-in. from the inner cone so that the torch can be moved forward.

12. Advance the puddle forward with a slight circular motion of the torch, reinsert the rod into the center of the puddle at the point of the inner cone, and let a drop or two of molten metal fill the puddle.





13. Withdraw the rod and advance the torch in a circular motion so that a continuous oval shaped puddle will form, then reinsert the rod as before and continue the procedure until the first weld is completed.

14. Before reaching the end of the plate, stop so that the molten metal will not drip off the plate.

15. Move ½-in. down the plate, and run another bead parallel to the first weld. Continue to lay parallel beads as plate space will permit.

16. Have instructor check work.

17. Cool and place all welded scrap in proper container. Clean area.

18. Check tools and materials and put in proper place.

STUDENT INFORMATION SHEET
WELDING

UNIT:	Oxyacetylene Welding Positions and Applications
TOPIC:	Oxyacetylene Positions and Applications
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to make oxyacetylene welds and check them for defects correctly.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to determine tip sizes and rod selection, use oxyacetylene welding in all positions, and understand the terms used in oxyacetylene welding.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with the oxyacetylene positions and applications include oral and written communications, reading concepts, and application of mathematical principles.*

Oxyacetylene Welding Applications
Terminology

Base metal is the metal to be welded.

Backfire is a sudden burning-back of the flame into the tip and the flame goes out with a loud “pop”.

Backhand welding is the use of the torch during welding so that the flame is directed back over the area that has been welded.

Note: *Usually used on thicker metal.*

Flashback is a fire burning inside the torch, causing a squealing or hissing sound.

Forehand welding is moving the torch across the metal, with the tip pointing in the direction to be welded.

727

Note: *Usually used on thinner metal.*

Fusion welding is the joining of two pieces of metal by heating the adjoining edges to the melting point, allowing them to flow together, and then cool.

Inner cone is the white part inside the neutral flame.

Melt-through is when the metal is heated to the point that melted metal forms on the back side of a weld.

Penetration is the depth the heat of the torch melts the metal during welding.

Puddling is heating the base metal to its melting point and moving the pool of molten metal steadily along the length of the base metal.

Root of weld is that part of a weld farthest from the application of weld heat and/or filler metal side.

Soapstone is a soft, chalky stone used for marking on metal.

Tack welding is placing a small weld on a piece of base metal to hold the metal into place.

Weave is the circular movement of the torch causing uniform patterns on the metal.

The Oxyacetylene Weld

Factors which affect the quality of an oxyacetylene weld

- Proper torch adjustment
- Angle of tip
- Distance of tip from base metal
- Movement of tip
- Rate of travel
- Proper tip size

Factors determining tip size selection

- Thickness of metal
- Size of welding rod

Factors determining rod selection

- Rod with similar properties as base metal

- Size of weld fillet

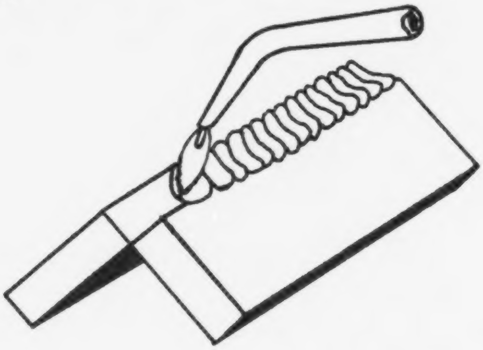
Properties of a good weld

- Weld metal is fused into base metal
  Note: *If metals are not fused, you have not made a weld.*
- The width is the same for the entire length of the bead
- The bead has a slightly rounded buildup
- The weld is straight or follows the proper path
- The surface has a clean appearance and is free of splatter
- Proper penetration into base metal

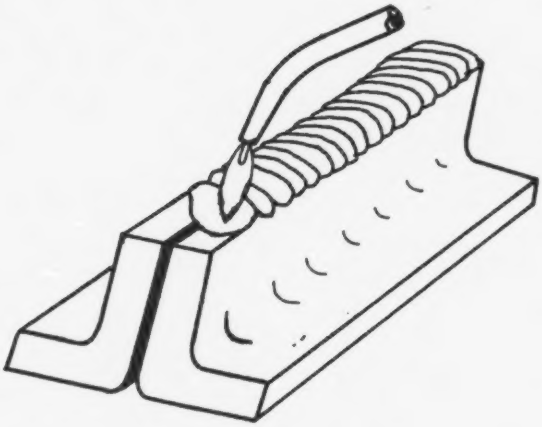
Position Welding

Types of welds that need no filler rod

- Outside corner

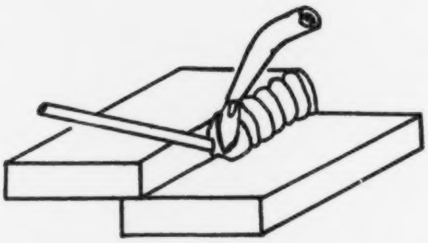


- Flange

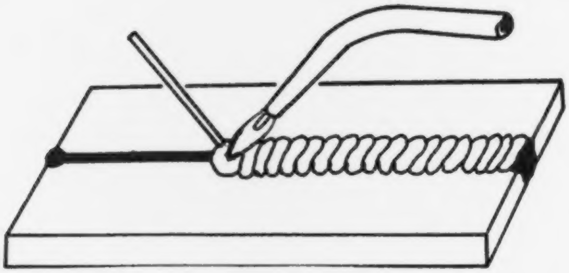


Types of welds that require filler rod

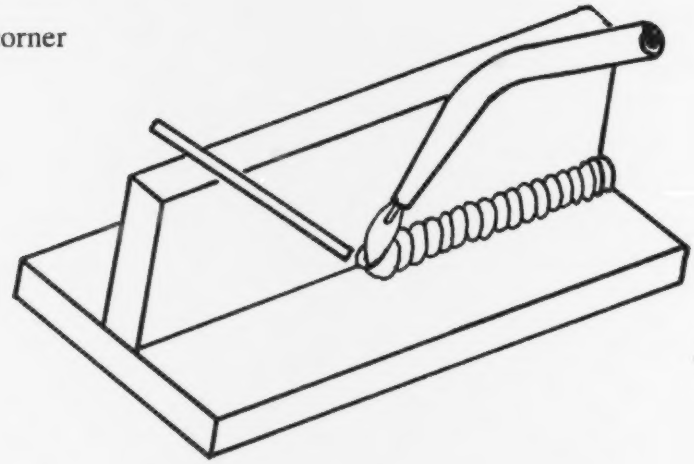
- Lap



- Butt

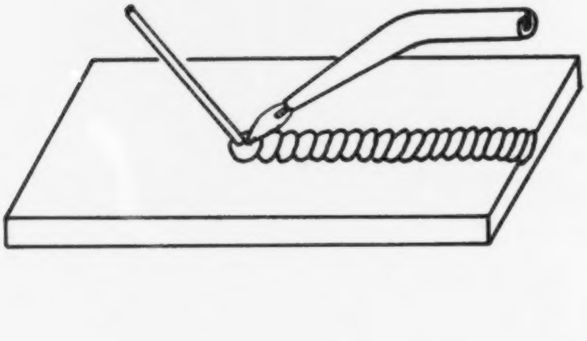


- Inside corner

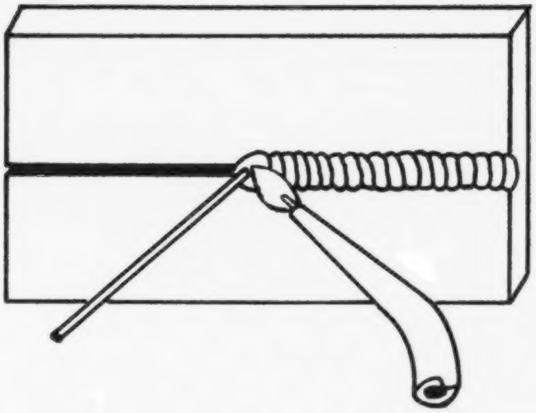


Weld positions

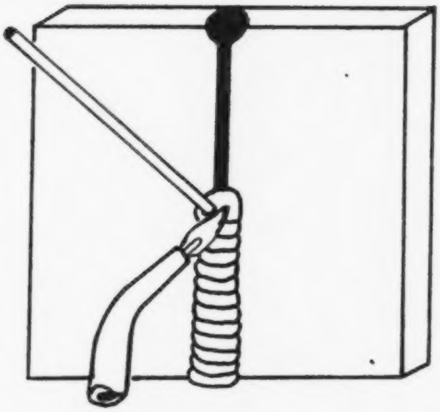
- Flat



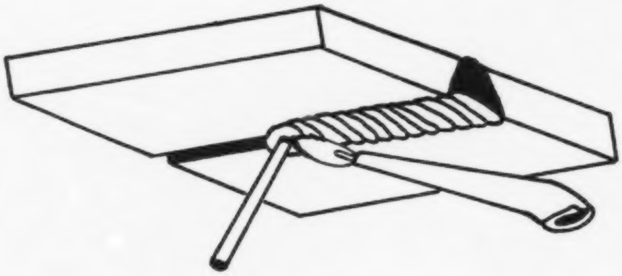
- Horizontal



- Vertical



- Overhead



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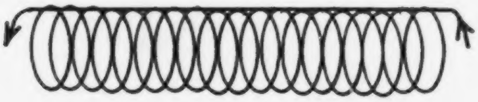
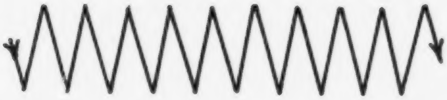
Oxyacetylene welding patterns for puddling

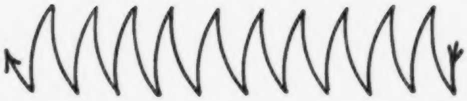
A.



B.



C.



Brazing

Advantages

1. Uses lower temperature in welding process
2. Can join unlike metals
3. Will weld metals that cannot easily be welded by other processes.
   Example: *Cast iron*
4. Does not melt base metal
5. Can be used on light gauge metals

Disadvantages

1. Weld is not as strong
2. Brazing materials are expensive

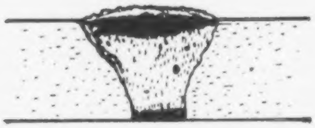
Preparation of metal required for brazing

- Clean metal surface to allow free flow of brass.
- Prepare castings that will be welded by V-ing out the crack or weld area. **Example:** *Crack in car exhaust manifold.*
- Preheat metal slightly and evenly.

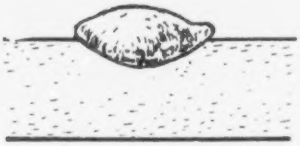
Purpose of flux

- Helps clean the base metal
- Eases flow of brass filler rod
- Allows brass filler rod to enter base metal pores
- Prevents oxidation of filler rod and base metal

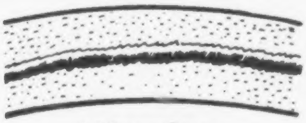
Common Problems in Welding



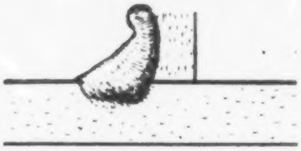
Porous Welds



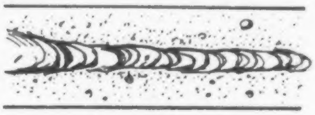
Poor Penetration



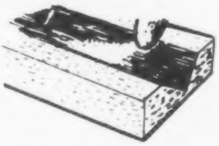
Warping



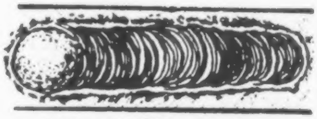
Undercutting



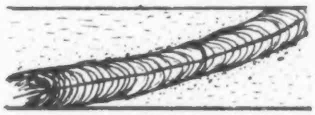
Splatter



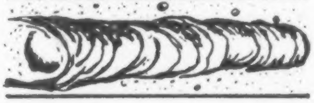
Magnetic Blow



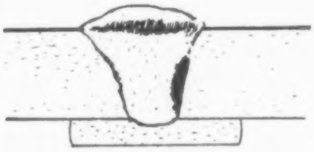
Weld Stresses



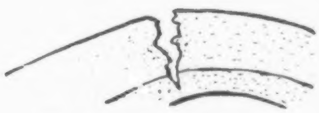
Cracked Welds



Poor Appearance



Poor Fusion



Brittle Welds

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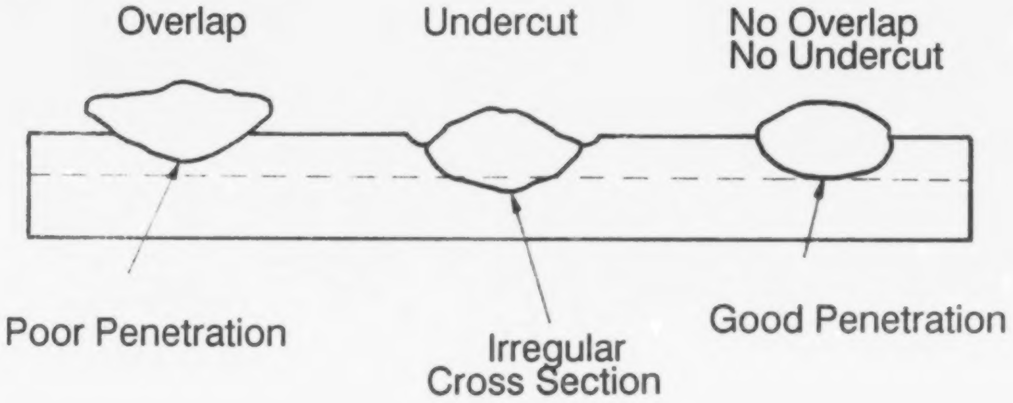
Properly & Improperly Formed Beads

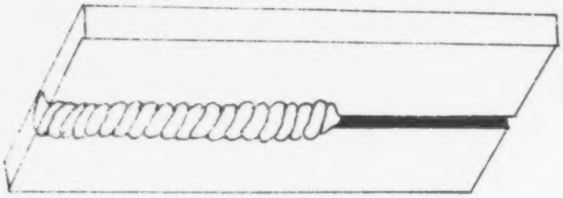

Overlap
Undercut
No Overlap
No Undercut
Poor Penetration
Irregular
Cross Section
Good Penetration

Overlap
1. Current too Low
2. Arc Length too Short
3. Rate of Travel too Fast

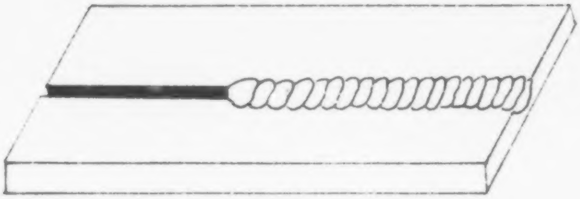
Undercut
1. Current too High
2. Arc Length too Long
3. Rate of Travel tooSlow

Proper Bead
1. Current Normal
2. Arc Length Normal
3. Correct Rate of Travel

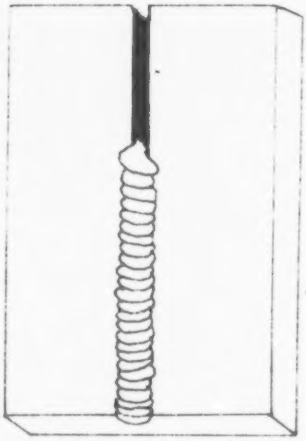
Welding Positions



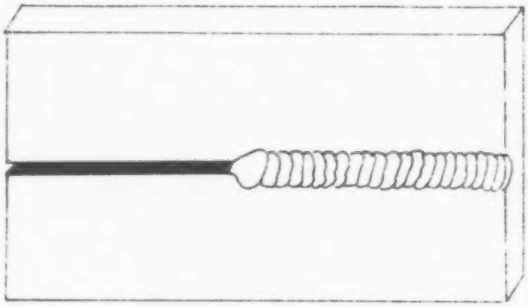
Overhead



Flat

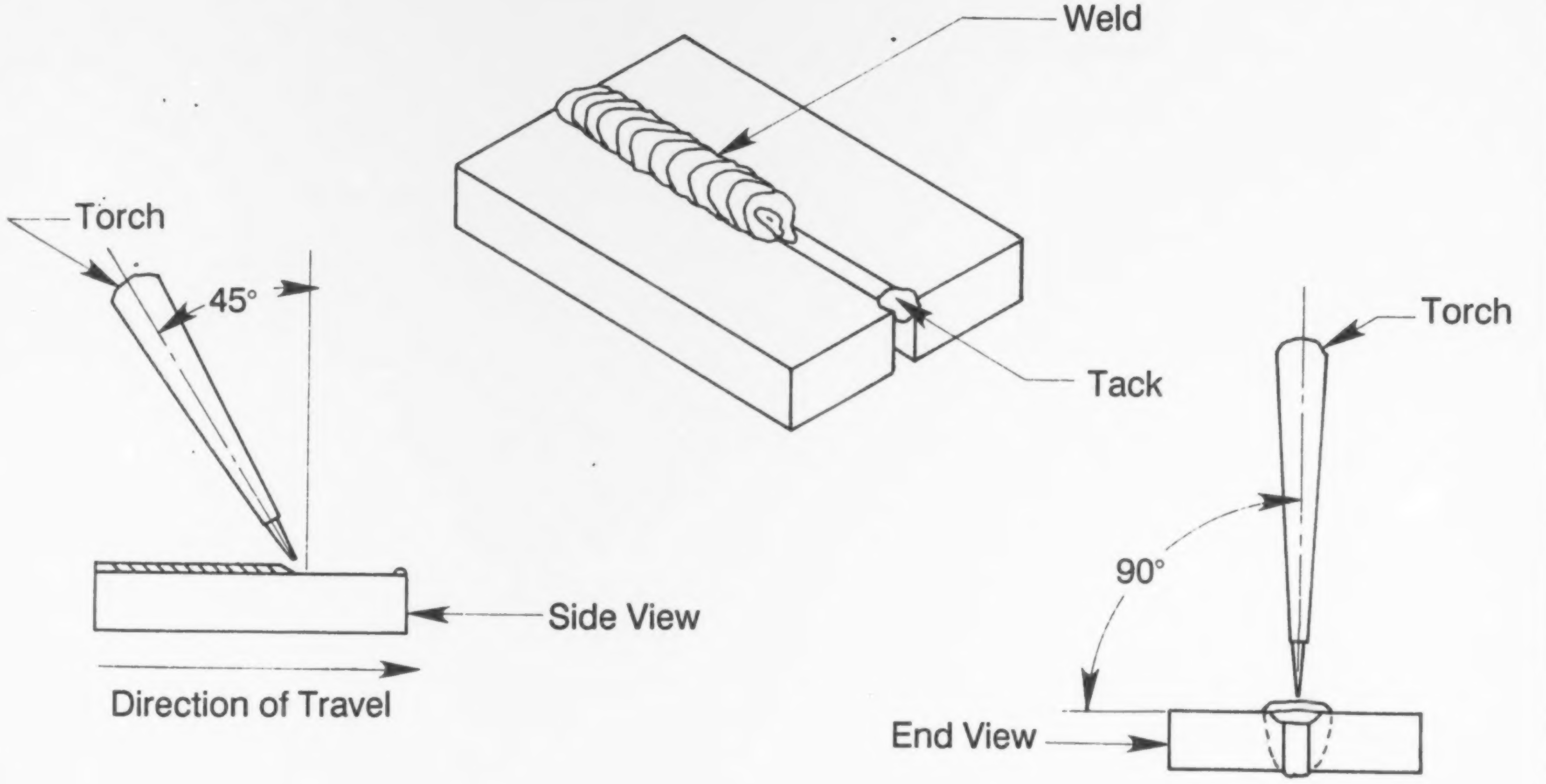


Vertical

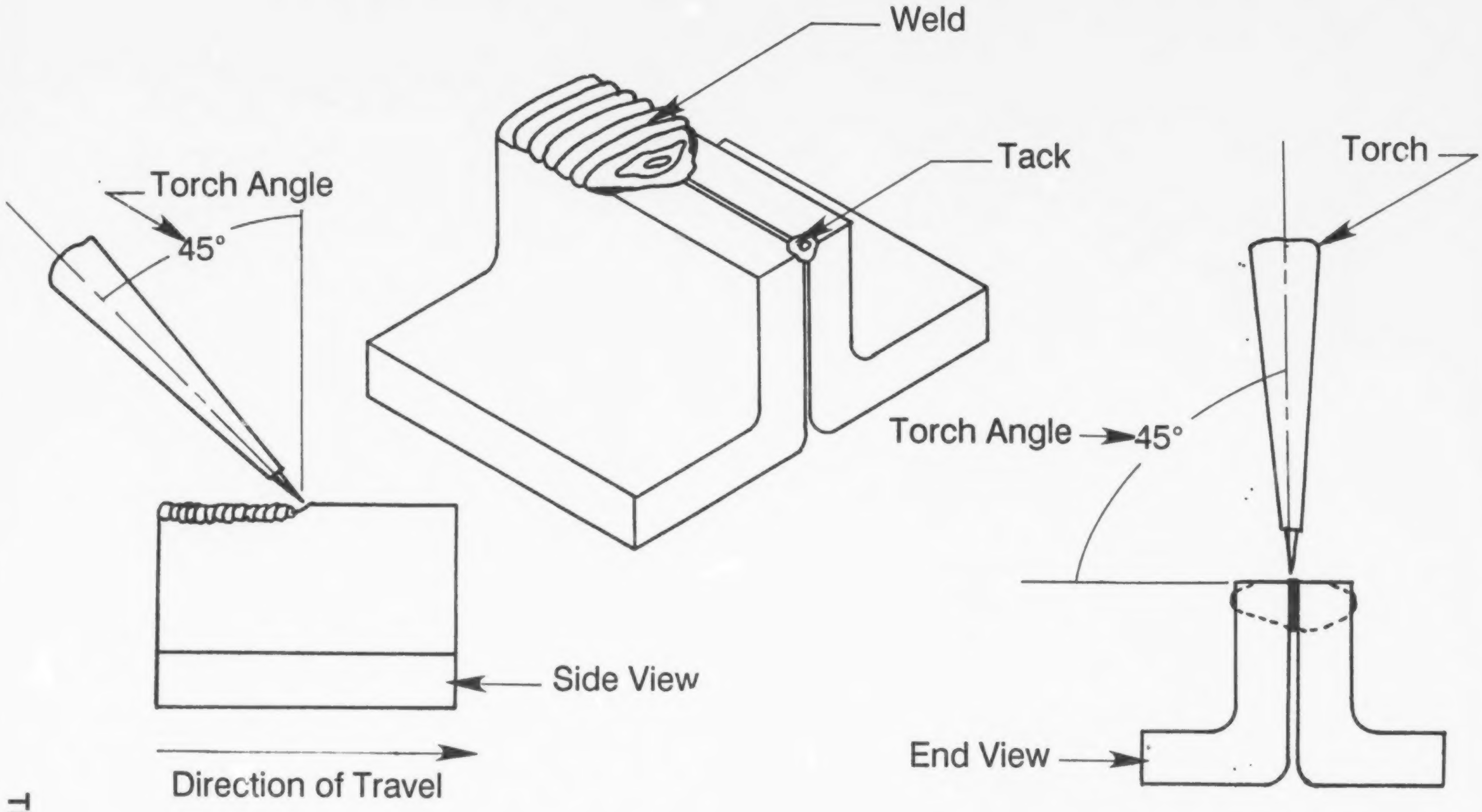


Horizontal

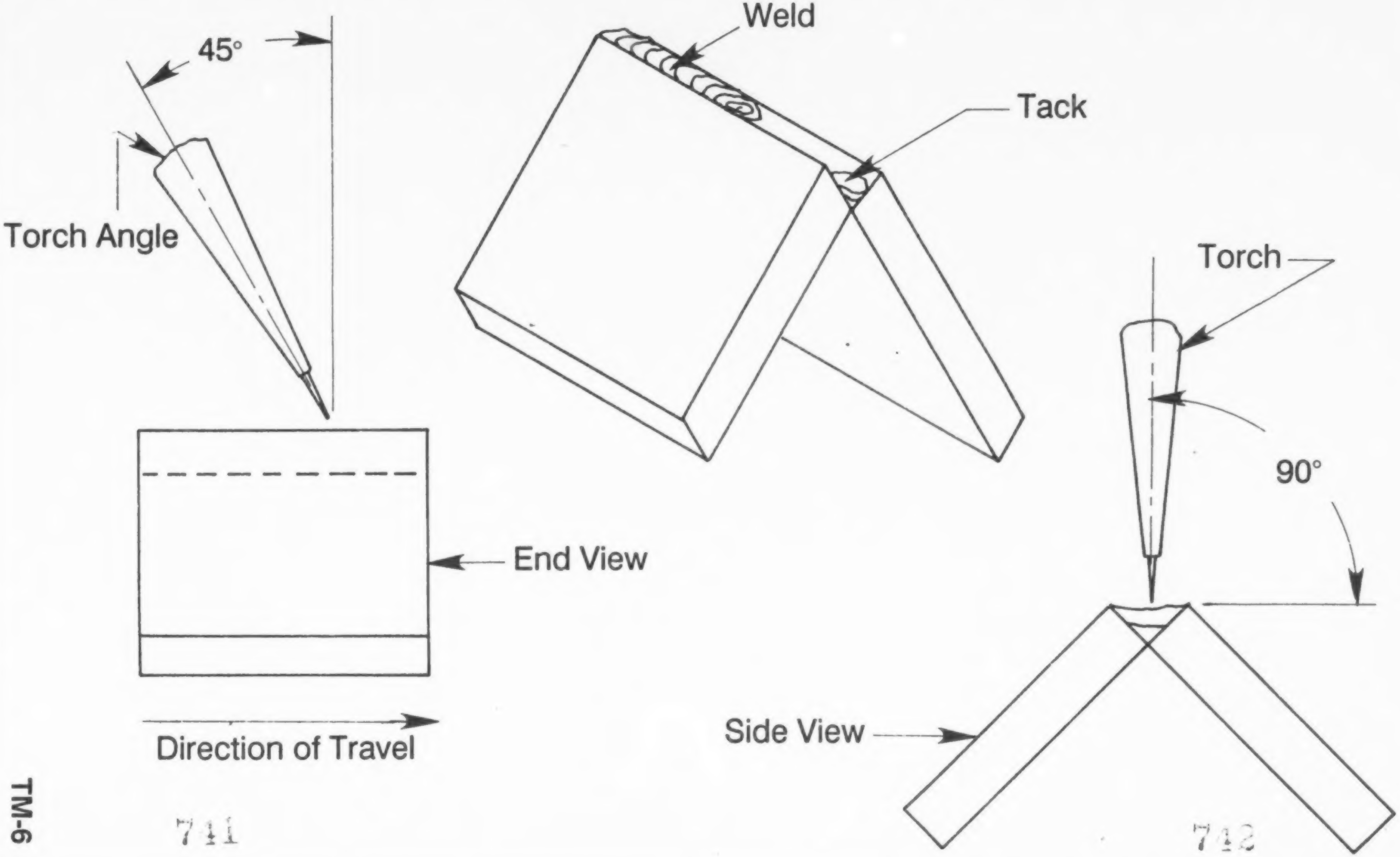
Flat Butt Weld (No Filler Rod)


Weld
Torch
45°
Torch
Tack
Side View
Direction of Travel
90°
End View

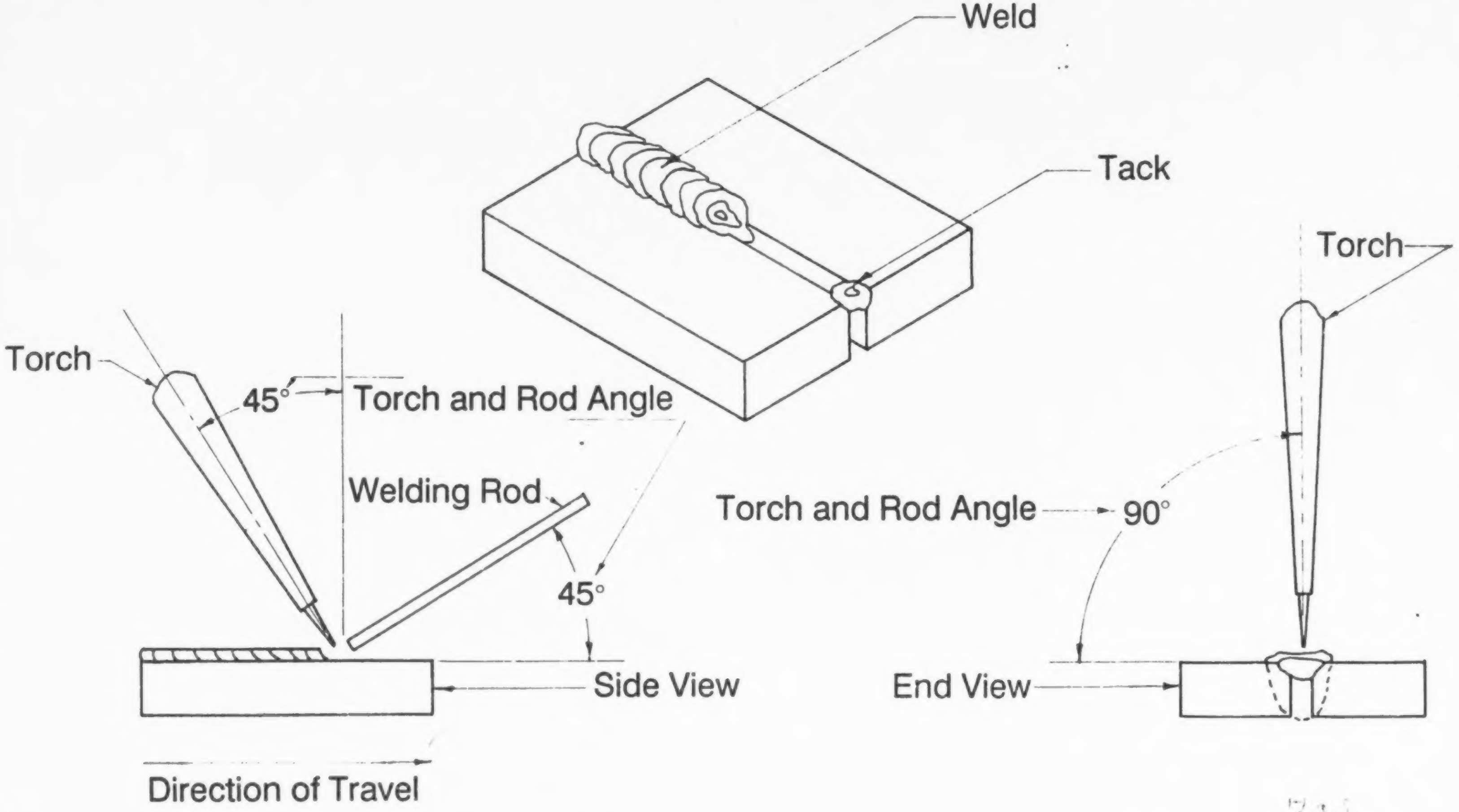
Flat Flange Weld (No Filler Rod)


Weld
Tack
Torch Angle
45°
Torch
Torch Angle
45°
Side View
End View
Direction of Travel

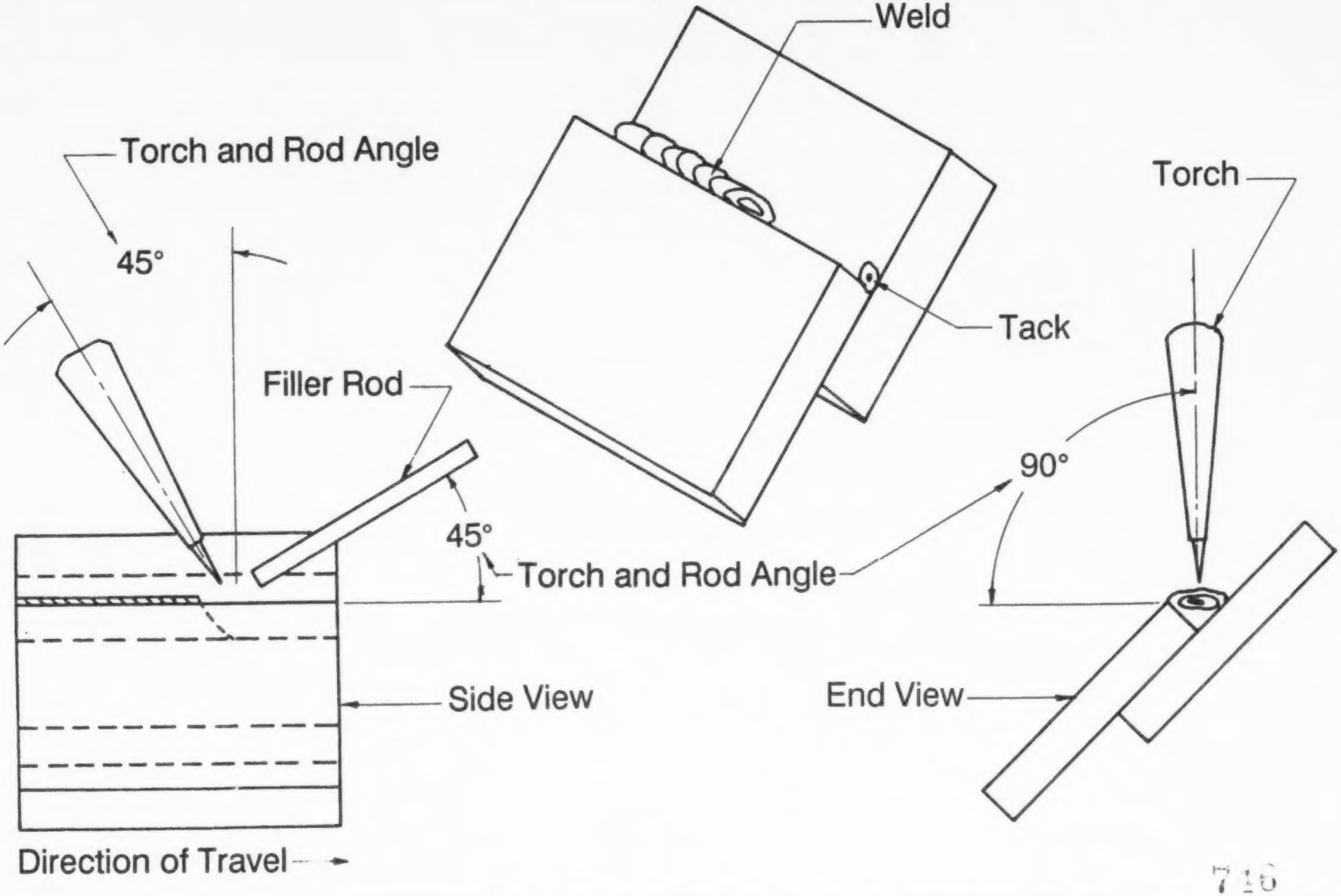
Flat Corner Weld (No Filler Rod)


45°
Torch Angle
Weld
Tack
End View
Direction of Travel
Torch
90°
Side View

Flat Butt Weld

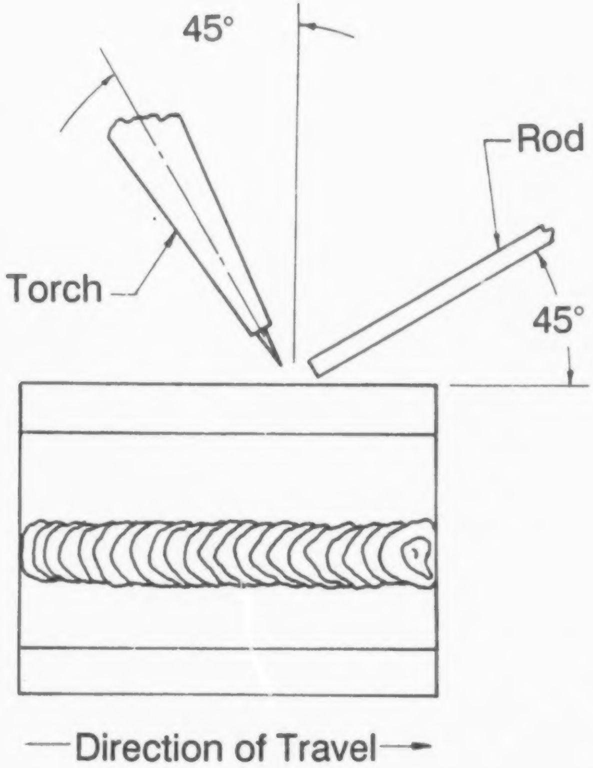

Weld
Tack
Torch
Torch
45°
Torch and Rod Angle
Welding Rod
45°
Side View
Direction of Travel
Torch and Rod Angle
90°
End View

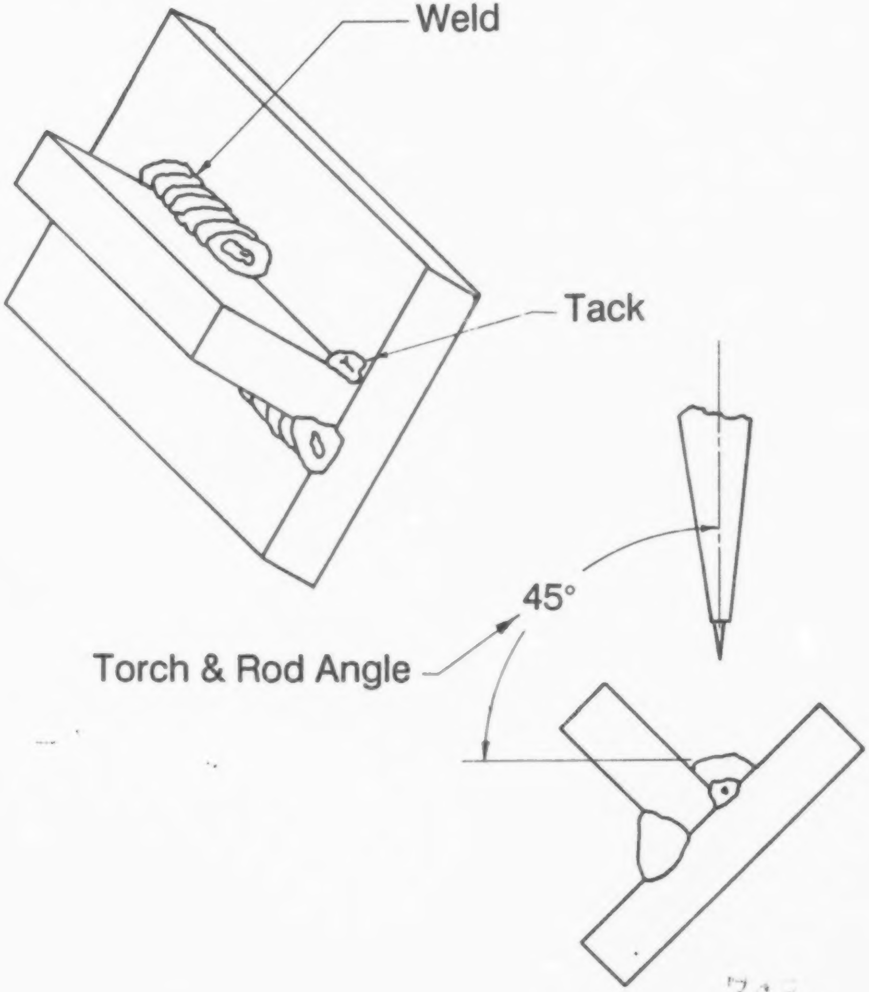
Flat Lap Weld


Weld
Torch and Rod Angle
45°
Filler Rod
45°
Torch and Rod Angle
Tack
Torch
90°
Side View
End View
Direction of Travel

TM-8

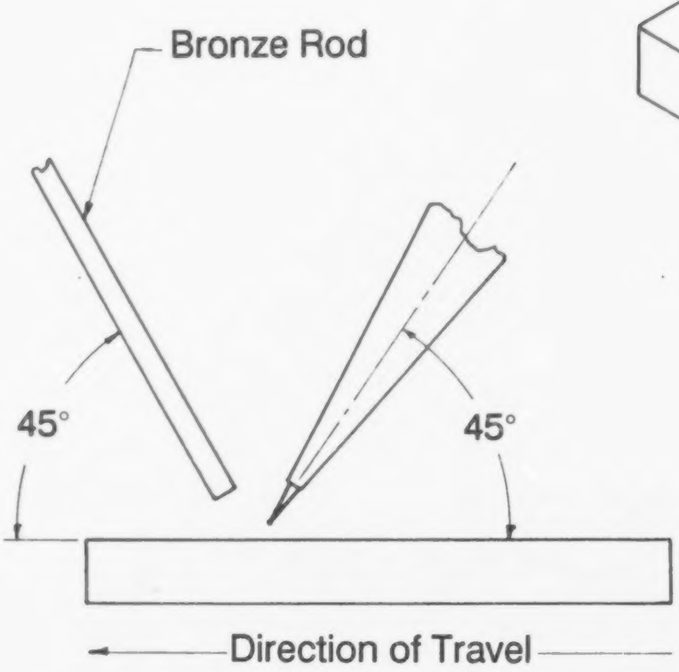
Flat Tee Weld

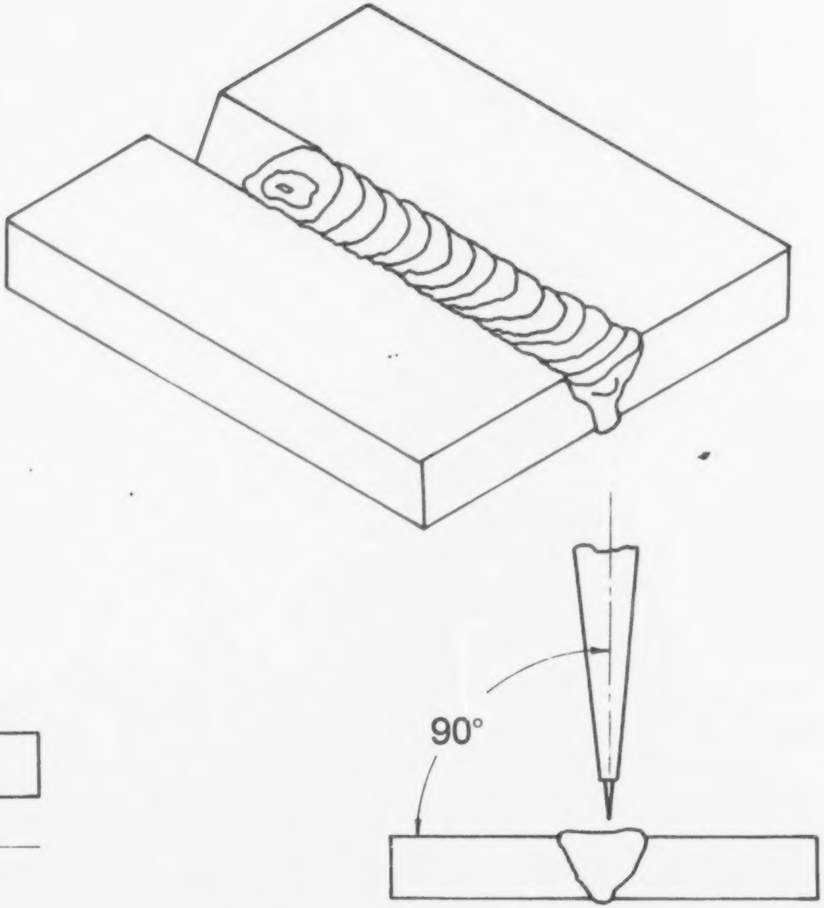

45°
Rod
Torch
45°
Direction of Travel


Weld
Tack
45°
Torch & Rod Angle

TM-9

Braze Welding


Bronze Rod
45°
45°
Direction of Travel



TM-10

ASSIGNMENT SHEET

WELDING

NAME ____________________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Oxyacetylene Positions and Applications

DIRECTIONS: Read the following questions and answer them in the spaces provided.

1. Match the terms associated with oxyacetylene welding with their definitions by placing the number in front of each term below in the correct blank.

    ____a. A soft, chalky stone used for marking on steel.

    ____b. Joining two pieces of metal by heating the adjoining edges to the melting point, allowing them to flow together, and then cool.

    ____c. The metal to be welded.

    ____d. The white part inside the neutral flame.

    ____e. The circular movement of the torch causing uniform patterns on the metal.

    ____f. A fire burning inside the torch, causing a squealing or hissing sound.

    ____g. A sudden burning-back of the flame into the tip and the flame goes out with a loud "pop".

    1. Inner cone
    2. Backfire
    3. Root of weld
    4. Base metal
    5. Fusion weld
    6. Flashback
    7. Weave
    8. Puddling

____h. The part of a weld farthest from the application of the weld heat and/or filler metal side.

____i. The depth the heat of the torch melts the metal during welding.

____j. Heating the base metal to its melting point and moving the pool of molten metal steadily along the length of the base metal.

9. Penetration

10. Soapstone

2. Circle the letter in front of each of the 5 factors which affect the quality of an oxyacetylene weld.

    a. Proper torch adjustment

    b. Brand of torch used

    c. Angle of tip

    d. Length of weld metal

    e. Distance of tip from base metal

    f. Movement of tip

    g. Rate of travel

3. Place a "√" in front of each of the factors that should be considered when selecting a tip size for welding.

    _____a. Thickness of metal

    _____b. Position of weld

    _____c. Size of welding rod

    _____d. Time of day

4. Place a "√" in front of the two factors that should be considered when selecting a filler rod.

    _____a. Size of welding torch

    _____b. Rod with similar properties of base metal

    _____c. Size of weld fillet

    _____d. Room temperature

5. Write **Yes** or **No** in the spaces at the left to identify the properties of a good weld.

_____a. Weld metal is fused into base metal.

_____b. Plenty of weld splatter.

_____c. Top of weld sinks in.

_____d. The width is the same for the entire length of the bead.

_____e. The bead is straight or follows the proper path.

6. Determine which welds do not require filler rod. (circle answer)

a. Outside corner weld, or inside corner weld

b. Flange weld, or V-butt weld

7. List the four positions used in welding.

a.

b.

c.

d.

8. Use "D" for disadvantage, and "**A**" for advantage for each of the following statements about brazing.

_____a. Brazing uses lower temperature in the welding process

_____b. Brazing materials are expensive

_____c. Brazing does not melt base material

_____d. Brazing can join unlike metals

_____e. Brazing can be done on light metals

_____f. Brazing will bond cast iron

9. List three steps in preparing metal for brazing.

a.

b.

c.

10. Point out the uses of flux. Circle the letter in front of each correct use.

a. Helps clean the base metal

b. Cleans the air of fumes

c. Eases flow of brass filler rod

d. Allows brass filler rod to enter base metal pores

e. Prevents oxidation of filler rod and base metal

f. Allows base metal to melt more quickly

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay a Flange Weld without Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a flange weld without filler rod correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Fire brick table
Welder's gloves
Goggles
Pliers
Cooling vat
Wire brush
No. 1 welding tip
Spark lighter
Coveralls
Two pieces of 16-gauge metal (approximately 2 x 3 in.)
Bend each into an L-shape down the 3-in. length with the flange being the same length on each.

GENERAL INSTRUCTIONS: Follow procedures to lay a flange weld without filler rod properly.

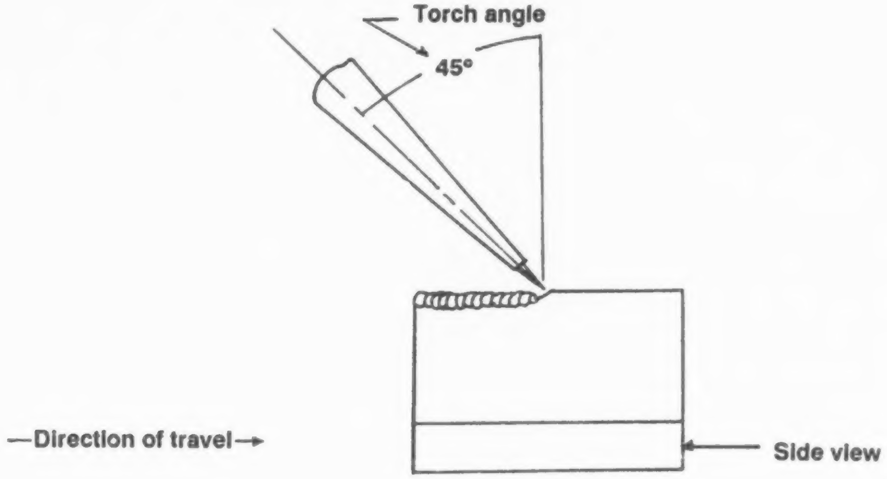
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, oxyacetylene goggles, and gloves.
2. Prepare metal.
3. Place metal on table with flanges pointed up and together.
4. Turn on oxyacetylene welding unit (3-5 PSI acetylene, 3-5 PSI oxygen).

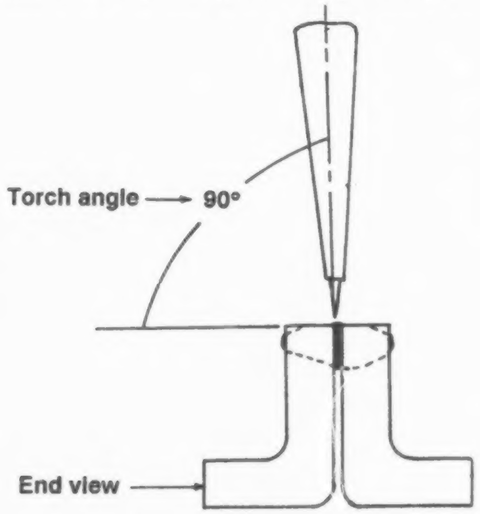
5. Light and adjust torch to a neutral flame.

6. Tack each end of flanges by placing flame about ⅛-in. from each corner of the flanges until they melt together.

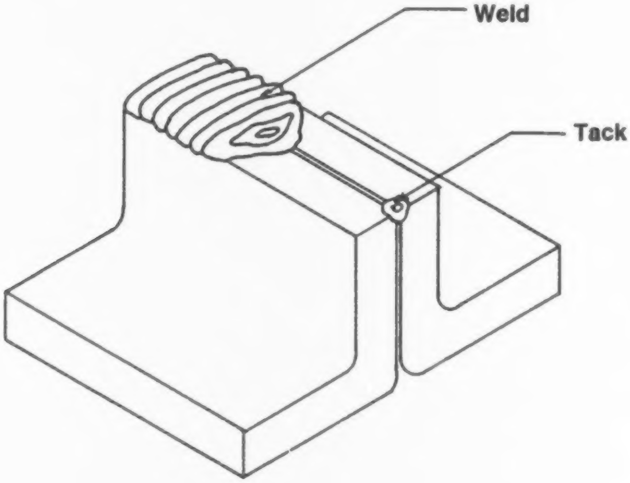
7. Hold torch at about 45 degrees away from the direction of the weld.


Torch angle
45°
—Direction of travel→
Side view

8. As the flange melts, move slowly along the flange using one of the weld patterns.


Torch angle → 90°
End view

9. Repeat this process until the weld becomes smooth and made easily.



10. Have instructor check work.

11. Clean tools and materials and put in proper place.

IV-2-JS-2

JOB SHEET
WELDING

NAME ______________________ DATE ______________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay an Outside Corner Weld without Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay an outside corner weld without filler rod correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Fire brick table
Welder's gloves
Goggles
Pliers
Cooling vat
Wire brush
No. 1 welding tip
Spark lighter
Coveralls
Two pieces of 16-gauge mild steel plate (approx. 2 x 3 in.)

GENERAL INSTRUCTIONS: Follow procedures to lay an outside corner weld without filler rod properly.

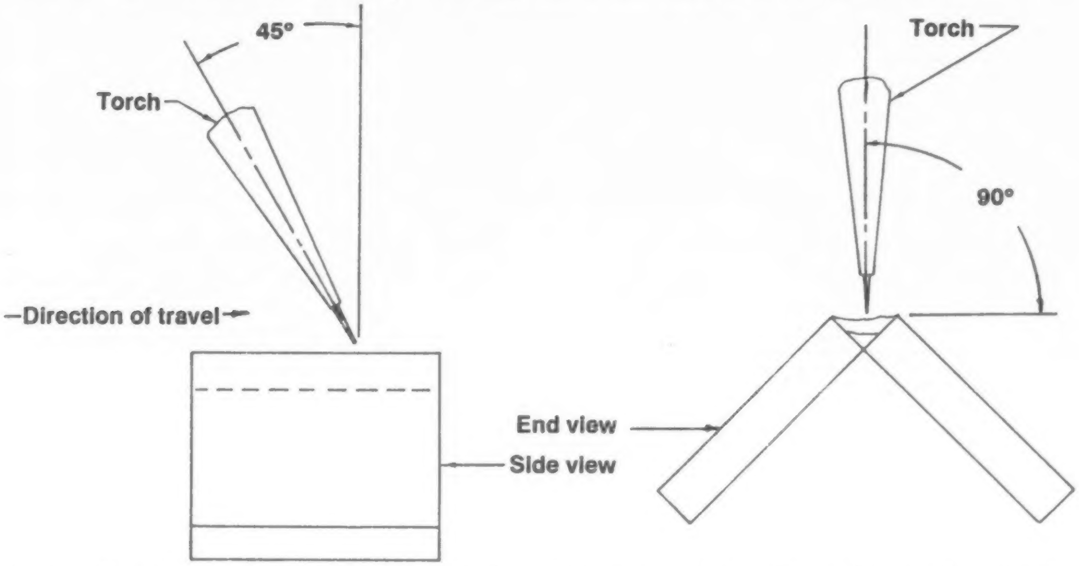
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, oxyacetylene glasses, and gloves.
2. Select metal.
3. Place metal on table in an upside down V position.
4. Turn on acetylene unit (3-5 PSI acetylene, 3-5 PSI oxygen).
5. Light and adjust torch to a neutral flame.

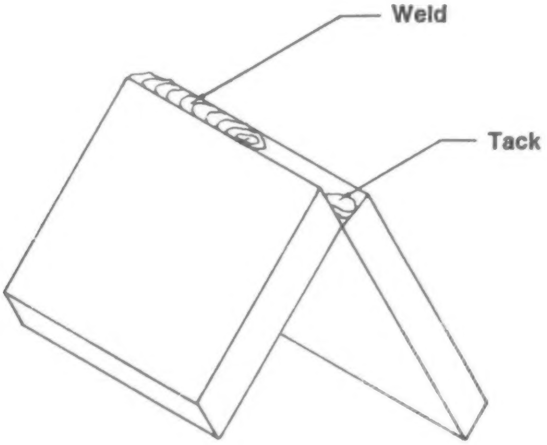
6. Tack the metal in place at each end.

7. Place inner cone 1/8- to 1/4-in. from corner.

8. Hold torch at 30 to 45 degrees away from the direction of the weld.


45°
Torch
—Direction of travel
Torch
90°
End view
Side view

9. As the corner of each place melts together, move slowly along the entire length of the material.



10. Repeat this process until the weld is smooth and made easily.

11. Have instructor check work.

12. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay a Flat Butt Weld with Proper Size Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a flat butt weld with the proper size filler rod correctly.

TOOLS AND EQUIPMENT:

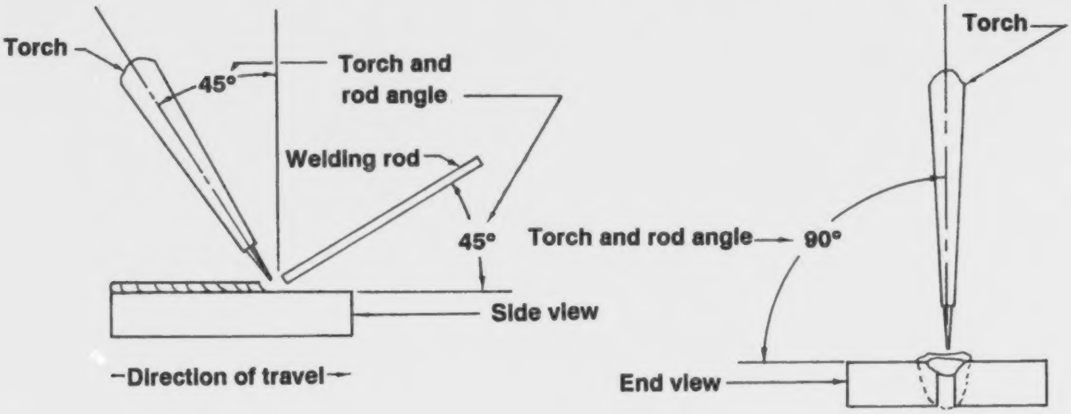
Oxyacetylene welding unit
Fire brick table
Welder's gloves
Goggles
Pliers
Cooling vat
Spark lighter
Wire brush
No. 1 welding tip
Coveralls
One piece of 16-gauge mild steel plate (approximately 4 x 6 in.)
1/16-in. filler rod (clothes hangers work as well)

GENERAL INSTRUCTIONS: Follow procedures to lay a flat butt weld with the proper size filler rod properly.

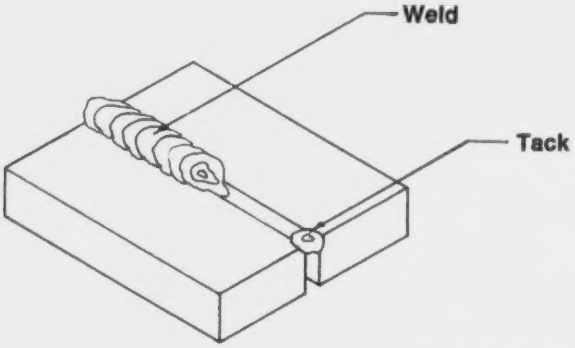
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on oxyacetylene glasses, coveralls, and gloves.
2. Prepare metal.
3. Turn on oxyacetylene welding unit (3-5 PSI acetylene, 3-5 PSI oxygen).
4. Light and adjust torch to a neutral flame.

5. Place inner cone about 1/8- to 1/4-in. away from the plate.
6. Hold torch at about 30 to 45 degrees away from the direction of the weld.


Torch
45°
Torch and rod angle
Welding rod
45°
Side view
–Direction of travel–
Torch
Torch and rod angle — 90°
End view

7. As the puddle forms, add filler rod to the front edge of the puddle until you get the proper buildup.
8. Move the puddle along with the torch using one of the weave patterns.



9. Add and withdraw the filler rod as you need more buildup metal deposited.
10. Keep the same amount of buildup the entire length of the weld.
11. Repeat the process until you can make a good weld easily.
12. Have instructor check work.
13. Clean tools and materials and put in proper place.

IV-2-JS-4

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay a Lap Weld with Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a lap weld with filler rod correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Fire brick table
Welder's gloves
Goggles
Pliers
Cooling vat
Wire brush
No. 1 welding tip
Spark lighter
Coveralls
Two pieces of 16-gauge, 2 x 3 in. metal
1/16-in. filler rod (clothes hangers work as well)

GENERAL INSTRUCTIONS: Follow procedures to lay a lap weld with filler rod properly.

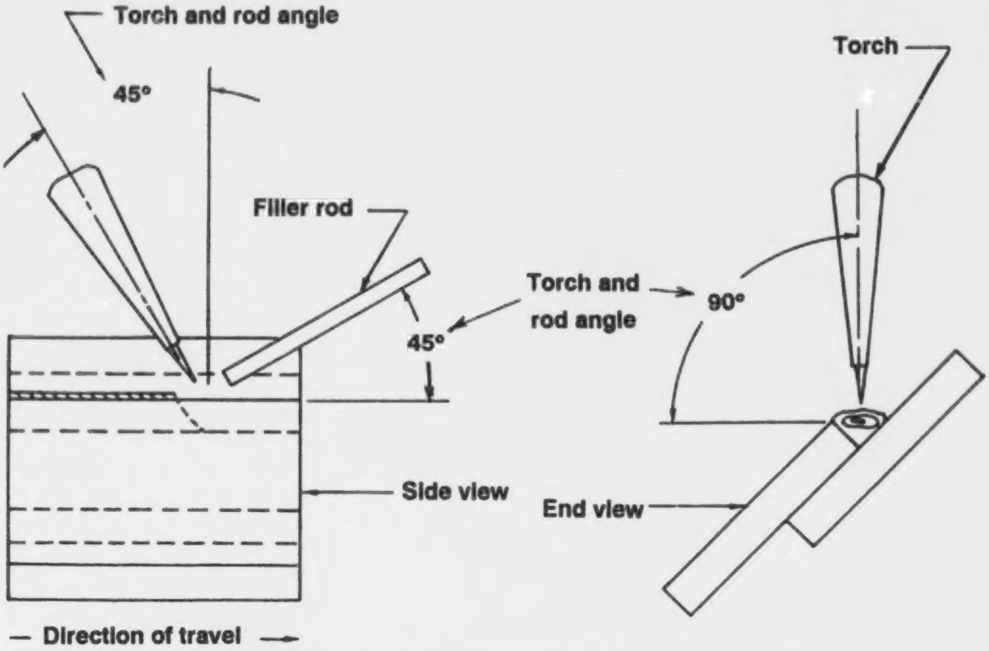
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on oxyacetylene glasses, coveralls, and gloves.
2. Prepare metal and place on the table with the 3-in. sides overlapping.
3. Turn on oxyacetylene welding unit (3-5 PSI acetylene, 3-5 PSI oxygen).
4. Light and adjust torch to a neutral flame.

5. Tack weld the two plates in place by melting the corners of the top plate to the bottom plate.

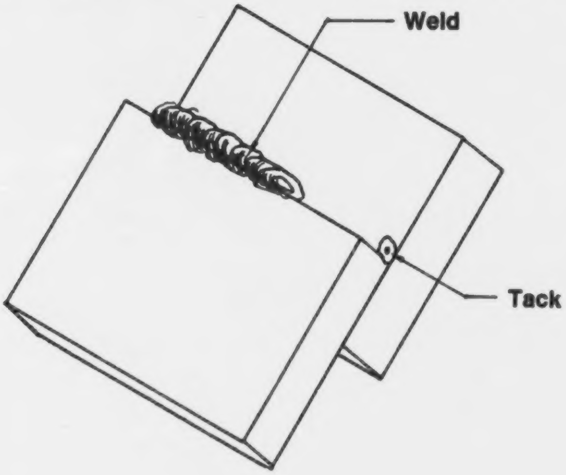
6. Place inner cone ⅛- to ¼-in. away from the bottom plate allowing the cone to slightly miss the top plate.

7. Hold the torch at about 45 degrees away from the direction of the weld and 45 degrees away from the top plate.


Torch and rod angle
45°
Filler rod
45°
Torch and
rod angle
Torch
90°
Side view
End view
Direction of travel

8. As the plates melt and form a puddle, add filler rod until you get the proper buildup.

9. Move the puddle along with the torch using one of the weave patterns.



10. Add and withdraw the filler rod as you need buildup on the weld area.
11. Keep the buildup the same over the entire weld length and bonded equally to the top and bottom plates.
12. Repeat the process until the weld can be made easily and has the proper appearance.
13. Have instructor check work.
14. Clean tools and materials and put in proper place.

IV-2-JS-5

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay an Inside Corner Weld with Filler Rod

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay an inside corner weld with filler rod correctly.

TOOLS AND EQUIPMENT:

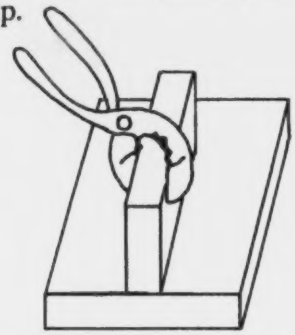
- Oxyacetylene welding unit
- Fire brick table
- Welder's gloves
- Goggles
- Pliers
- Cooling vat
- Wire brush
- No. 1 welding tip
- Spark lighter
- Coveralls
- Two pieces of 16-gauge metal (approx. 2 x 3-in.)
- 1/16-in. filler rod (clothes hangers work as well)

GENERAL INSTRUCTIONS: Follow procedures to lay an inside corner weld with filler rod properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, oxyacetylene goggles, and gloves.
2. Prepare metal.
3. Turn on the oxyacetylene welding unit (3-5 PSI acetylene, 3-5 PSI oxygen).
4. Light and adjust torch to a neutral flame.

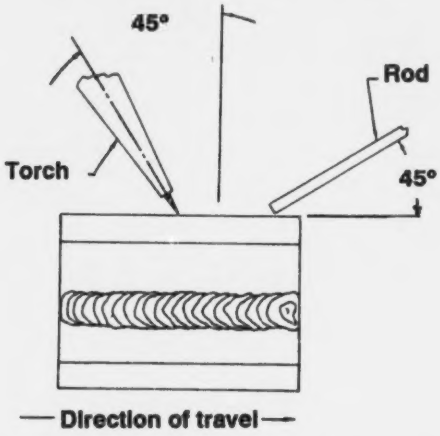
5. Holding one plate on the 2-in. side with pliers, place it in the middle on the other plate with the ends lined up.

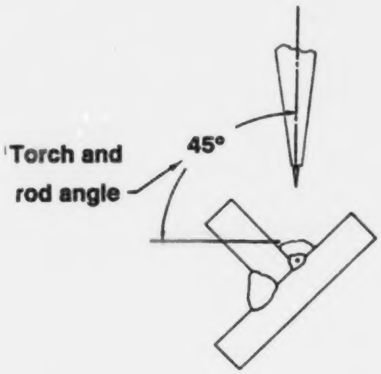


6. Tack the plate in place by heating the corners of the top plate where they meet the bottom plate until they melt together.

7. Place inner cone 1/8- to 1/4-in. away from the corner formed by the two plates.

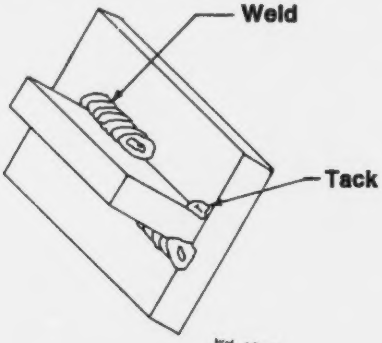
8. Hold the torch at about 45 degrees away from the direction of the weld and 45 degrees away from the top plate.


45°
Rod
Torch
45°
— Direction of travel —


Torch and
rod angle
45°

9. As the plates melt and form a puddle, add filler rod until you get the proper buildup.

10. Move the puddle along with the torch using one of the weave patterns.



766

11. Add and withdraw filler rod as buildup is needed on the weld area.
12. Keep the buildup the same over the entire weld length and bonding equally with the top and bottom plates.
13. Repeat the process until the weld can be made easily and has the proper appearance.
14. Have instructor check work.
15. Clean tools and materials and put in proper place.

JOB SHEET

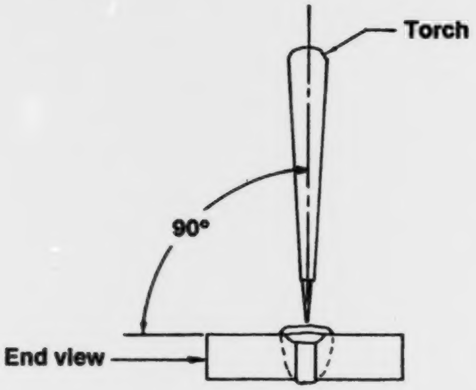
WELDING

NAME ______________________________ **DATE** ________________

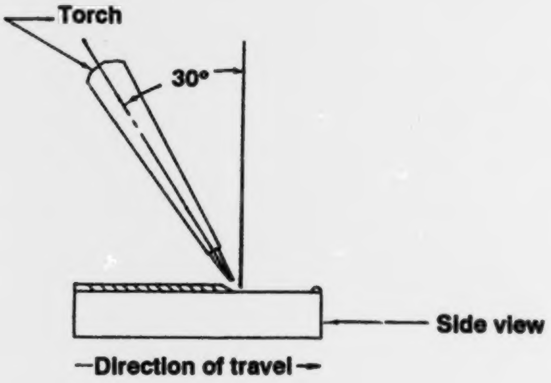
UNIT:	Oxyacetylene Welding Positions and Applications
TOPIC:	Lay a Butt Joint without Filler Rod
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to lay a butt joint without filler rod correctly.
TOOLS AND EQUIPMENT:	Torch tip for welding 1/16-in. metal Scrap 1/16-in. metal Protective clothing Safety goggles
GENERAL INSTRUCTIONS:	Follow procedures to lay a butt joint without filler rod properly.
PROCEDURES AND/OR TASKS:	**Note:** *Follow safety precautions.*

1. Put on oxyacetylene goggles, gloves, and coveralls.
2. Prepare metal.
3. Turn on oxyacetylene unit (3 to 5 PSI acetylene and 3 to 5 PSI oxygen).
4. Light the torch and adjust to a neutral flame.

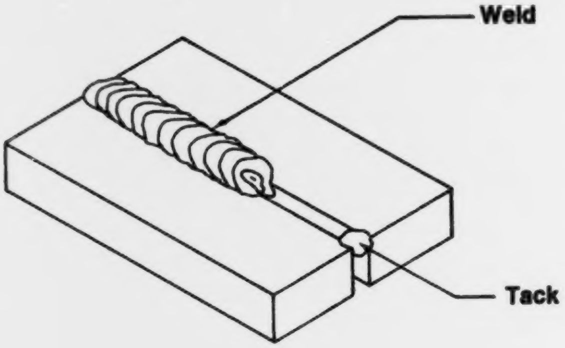
5. Place inner cone about 1/8- to 1/4-in. away from the direction of the weld.


Torch
90°
End view

6. Hold torch at about 30 to 45 degrees away from the direction of the weld.


Torch
30°
Side view
Direction of travel

7. As a puddle forms, move the torch along slowly, using one of the weave patterns.



8. Repeat this beading process until a good weld becomes easy to produce.
9. If popping occurs:
    a. Clean metal.
    b. Raise tip slightly.
    c. Clean tip.
    d. Tighten nut holding tip on torch.
    e. Replace O-rings on tip.
    f. Adjust torch flame.
10. If a melt-through occurs:
    a. Adjust heat of torch to a smaller inner core.
    b. Place metal on a back up plate and clamp to it.
    c. Clean rust or dirt from metal.
11. Turn in finished work to the instructor.
12. Roll up hoses.
13. Place torch and welding dolly in a safe place.

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IV-2-JS-7

JOB SHEET

WELDING

NAME ________________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay a Back Hand Butt Joint on Heavy Steel Plate

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a back hand butt joint on heavy steel plate correctly.

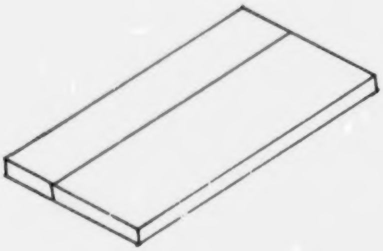
TOOLS AND EQUIPMENT:

- Welding tip for 1/4 -in. plate
- Two scrap plates 1/4 -in. thick
- 1/8-in. filler rod
- Protective clothing
- Vise
- Cooling vat
- Safety goggles

GENERAL INSTRUCTIONS: Follow procedures to lay a back hand butt joint on a heavy steel plate properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on protective clothing.
2. Prepare metal.

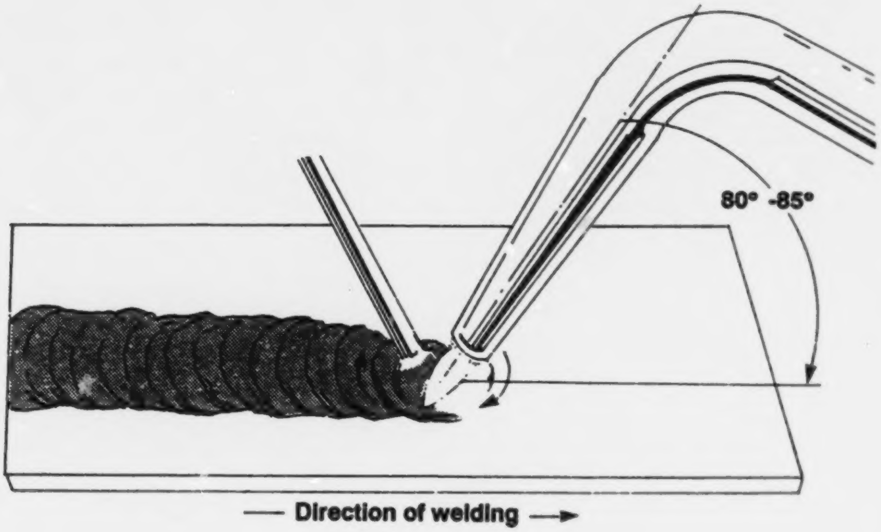


3. Turn on oxyacetylene unit (3 to 5 PSI acetylene and 3 to 5 PSI oxygen).

4. Light and adjust torch to a neutral flame.

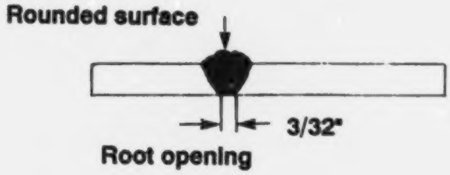
5. Tack weld plates 3/32-in. apart.

6. Establish a puddle on the left edge of the joint and proceed with the weld using a weaving pattern in the backhand position.


80° -85°
— Direction of welding →

7. As the weld is moved along, watch the bead and alter the torch angle until a weld with good appearance is produced.

8. Repeat the process until the weld can be made and has good appearance and penetration.


Rounded surface
3/32"
Root opening

JOB SHEET
WELDING

NAME ______________________ **DATE** ______________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Lay a Beveled Butt Weld on Heavy Steel Plate

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a beveled butt weld on a heavy steel plate correctly.

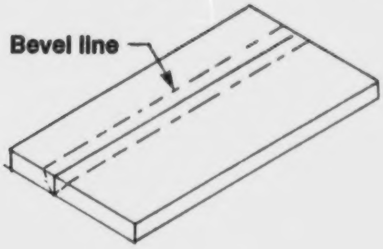
TOOLS AND EQUIPMENT:

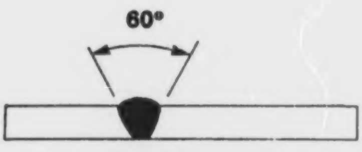
- Welding tip for ⅜-in. steel plate
- Two scrap plates ⅜-in. thick
- ⅛-in. steel filler rod
- Protective clothing
- Bench or hand grinder
- Hacksaw
- Safety goggles

GENERAL INSTRUCTIONS: Follow procedures to lay a beveled butt weld on a heavy steel plate properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on protective clothing.
2. Prepare metal by grinding a 60 degree bevel along the edges.





Beveled butt weld

773

3. Turn on oxyacetylene unit and set to proper pressures.

4. Light and adjust the torch to a neutral flame.

5. Tack the plates together on each end.

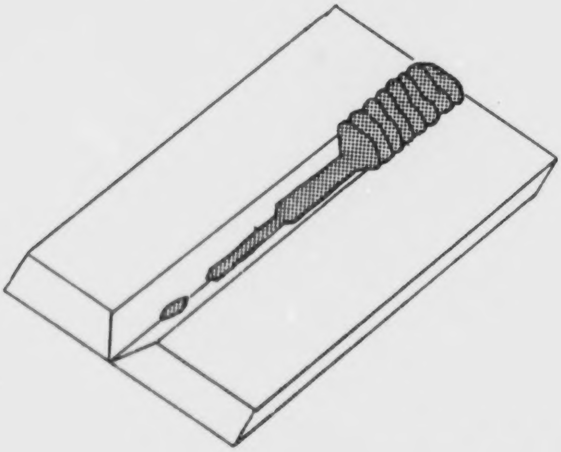
6. Make a root weld in the bottom of the groove with the flame angle about 60 to 75 degrees.

   Note: *If there is a tendency to burn through, try a smaller flame angle.*

7. Make a second pass with a weave pattern and increase the flame angle.

8. Make a third pass with a wider weave pattern.

   Note: *This should bring you flush with the top surface of the metal. It is important at this point not to produce a weld that is too wide. The weld should not be over 1/8-in. wider than the top opening.*



9. Cut a section from the weld and examine the weld area for proper fusion.

   Note: *Air-cool the weld. DO NOT cool it in water!*

10. Repeat the process until the weld can be made easily with a good appearance.

11. Turn in finished work to the instructor for testing.

12. Roll up hoses.

13. Place torch and welding dolly in a safe place.

IV-2-JS-9

JOB SHEET

WELDING

NAME ______________________ **DATE** ______________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Backhand Weld a Beveled Butt Joint

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to backhand weld a beveled butt joint correctly.

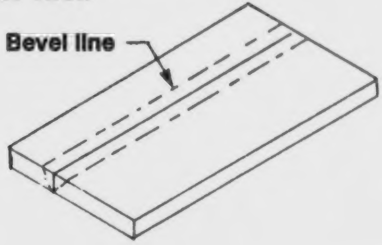
TOOLS AND EQUIPMENT:

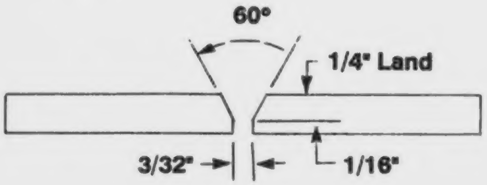
- Welding tip for 5/16-in. steel plate
- Two scrap plates 5/16-in. thick
- 3/16-in. filler rod
- Protective clothing
- Bench or hand grinder
- Hacksaw
- Safety goggles

GENERAL INSTRUCTIONS: Follow procedures to backhand weld a beveled butt joint properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on protective clothing.
2. Prepare metal by grinding edges 60 degrees at the corners, but leave a 1/16-in. straight, parallel root.





3. Adjust the oxyacetylene unit (3 to 5 PSI acetylene and 3 to 5 PSI oxygen).
4. Light and adjust torch to neutral flame.
5. Tack plates $\frac{1}{16}$-in. apart.
6. Make root pass with the backhand method.

   Note: *The rod may have to be removed from the puddle with a dipping motion to allow the heat to melt the root of the base metal.*

7. Make the second pass with the forehand method and a weave pattern.
8. Cut a section from weld to check for penetration and fusion.

   Note: *Air-cool only. **DO NOT** cool in water.*

9. Repeat the process until the weld can be made easily with a good appearance.
10. Turn in finished work to the instructor for testing.
11. Roll up hoses.
12. Place torch and welding dolly in a safe place.

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IV-2-JS-10

JOB SHEET

WELDING

NAME ______________________________ **DATE** __________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Braze a Butt Joint

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to braze a butt joint correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit
Fire brick table
Welder's gloves
Goggles
Pliers
Cooling vat
Wire brush
No. 1 welding tip
Spark lighter
Coveralls
Two pieces of 16-gauge metal (approx. 2 x 3 in.)
1/16-in. bronze filler rod
Welding flux

GENERAL INSTRUCTIONS: Follow procedures to braze a butt joint properly.

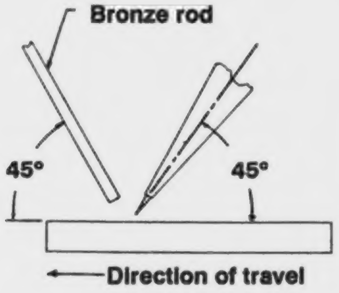
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

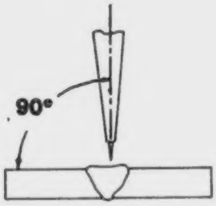
1. Put on coveralls, oxyacetylene goggles, and gloves.
2. Prepare metal and place on table leaving 1/16-in. gap down the 3-in. lengths.
3. Turn on oxyacetylene welding unit (3-5 PSI acetylene, 3-5 PSI oxygen).
4. Light and adjust torch to a neutral flame.
5. Preheat the brazing rod end approximately 1-in. in length and dip in flux.

6. Tack weld plate in place at each end of the gap.

7. Place the inner cone about 1/8- to 1/4-in. away from the weld plate gap.

8. Hold the torch about 45 degrees off of the plate and leaning away from the direction of travel.

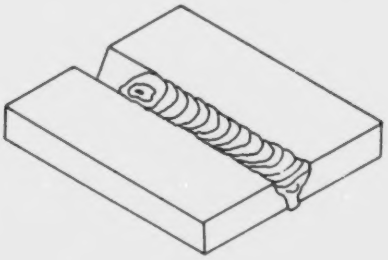




9. Heat the plates at the starting point of the weld until the metal **begins** to get red.

CAUTION: Do not overheat the metal.

10. Begin depositing filler rod as you move a puddle of brass along the weld.



11. Reduce the rate of travel if the brass forms drops.

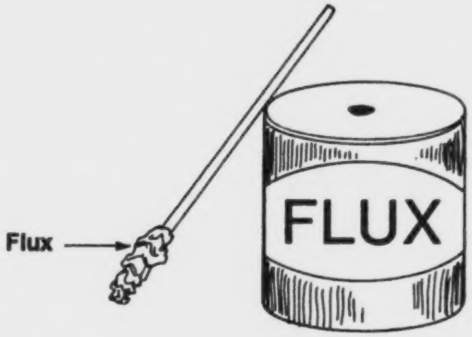
12. Lower the torch temperature if the brass tends to boil away.

Note: *Watch the base metal color.*

13. Add and withdraw filler rod to produce a slight buildup.

14. Keep the amount of buildup the same over the entire length of the weld.

15. Dip the rod into the flux when it is melted away.



16. Repeat this welding technique until it is done easily and becomes uniform in appearance.

17. Have instructor check work.

18. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Oxyacetylene Welding Positions and Applications

TOPIC: Braze Weld a Lap Joint in the Horizontal Position

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B), (ddd)(3)(C)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to braze weld a lap joint in the horizontal position correctly.

TOOLS AND EQUIPMENT:

Oxyacetylene welding unit with brazing tip
Welding goggles, safety glasses, and face shield
Welding gloves
Portable grinder
Vise
Pliers
Steel plates as selected by instructor
Bronze rod as selected by instructor
Flux as selected by instructor
Fire brick work table
Chipping hammer and wire brush

GENERAL INSTRUCTIONS: Follow procedures to braze weld a lap joint in the horizontal position properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Check work area to assure that it is free of flammable materials and properly ventilated, and note the location of the nearest fire extinguisher.
2. Place selected pieces of metal in vise and grind surfaces and edges to remove oxides.

   CAUTION: Always wear safety glasses and a face shield when grinding.

3. Position pieces of metal on fire brick and align to make a lap joint.

4. Select recommended brazing tip and put it on the torch finger tightly.

5. Set up equipment and light torch according to safety procedures previously outlined.

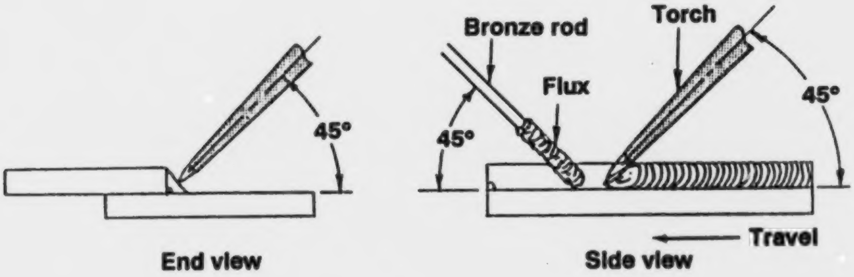
6. Adjust to slightly oxidizing flame.

7. Place rod so that half of it extends over the work table, hold the free end, then melt the rod in half to make it easier to handle and safer to work with.

8. Heat rod slightly and dip in flux, if required.

9. Tack both corners of each side of the joint.

10. Hold the torch at approximately a 45 degree work angle and a 45 degree travel angle, and move down until the flame is about 1/8-in. from the surface of the metal at the very corner of the joint.



11. Concentrate heat on the edge of the bottom plate first, then with a slightly circular motion, move the flame up and heat the top plate until both plates are dull red

12. Position the flame in the center of the joint, then insert the rod into the cone of the flame.

13. Allow a drip of molten bronze to fill the joint.

14. Withdraw rod a short distance, move the flame forward in a slight circular motion, then reinsert the rod to allow more molten bronze to enter the joint.

15. Check the rod frequently to make sure it has flux on it, and when the flux is gone, remove the rod and withdraw the flame slightly from the joint as you quickly dip the rod in flux again.

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16. Move the flame back into the center of the joint and continue the procedure until the joint is completely brazed.

17. Stop just as you cover the tack weld so molten bronze will not dip off the end of the joint.

18. Shut torch off.

19. Inspect bead for defects, especially leg lengths, bead width and height, and uniform fusion with the base metals.

20. Turn metal over with the pliers and clean oxidation from other side.

21. Relight torch, adjust to a slightly oxidizing flame, and repeat the procedure on the other side of the joint.

    Note: *The other side may require more heat.*

22. Shut off torch.

23. Clean and inspect.

24. Have your instructor check your work.

25. Clean up area and check tools and materials in or prepare for next job sheet as directed by your instructor.

STUDENT INFORMATION SHEET

WELDING

UNIT: Using the Cutting Torch

TOPIC: The Cutting Torch

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

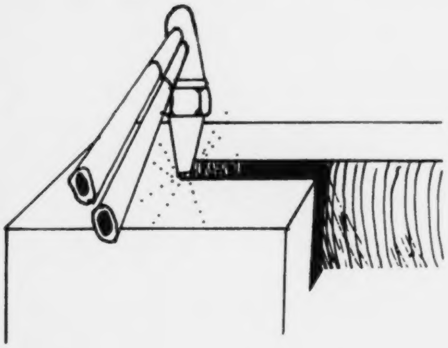
UNIT OBJECTIVE: After completing this unit, the student(s) will be able to identify parts of the cutting torch and problems resulting from improper use or adjustment of the cutting torch.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to adjust, cut, and bevel with the oxyacetylene torch correctly.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with the cutting torch include science, oral and written communications, and application of mathematical principles.*

The Cutting Torch Terminology

Backfire is a sudden burning of the flame back into the torch as the flame goes out with a "pop."



Drag line is the line formed on the metal being cut which appears to be lagging behind at the bottom of the cut.

Flame cutting is the process by which steel is removed by heating it to the melting point and then rapidly oxidizing it with pure oxygen under pressure.

Flashback is the fire burning inside the torch.

Kerf is the slot where metal was removed in the form of oxides during the cutting process.

Oxidizing is the combining of oxygen with steel, forming a scale or slag.

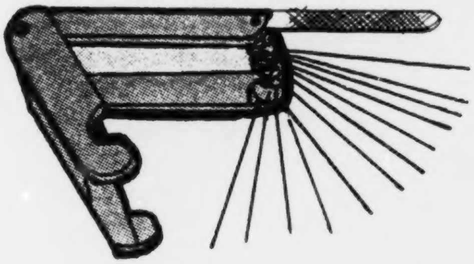
Oxides are the rust, corrosion, scale coating, or slag.

Preheat orifice is the part of the cutting tip which mixes the gases to produce a preheat flame.

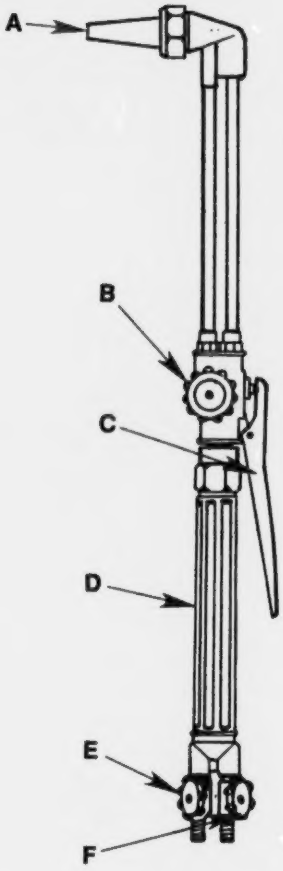
Preheat time is heating the metal to its melting temperature at the starting point of a cut.

Slag is the deposits or oxides left after a cut has been made.

Tip cleaner is a tool with different-sized wires used to remove carbon deposits from welding tips.



The Cutting Torch



- **A.** Cutting tip
- **B.** Oxygen pre-heat valve
- **C.** Cutting lever
- **D.** Torch body
- **E.** Acetylene torch valve
- **F.** Oxygen torch valve

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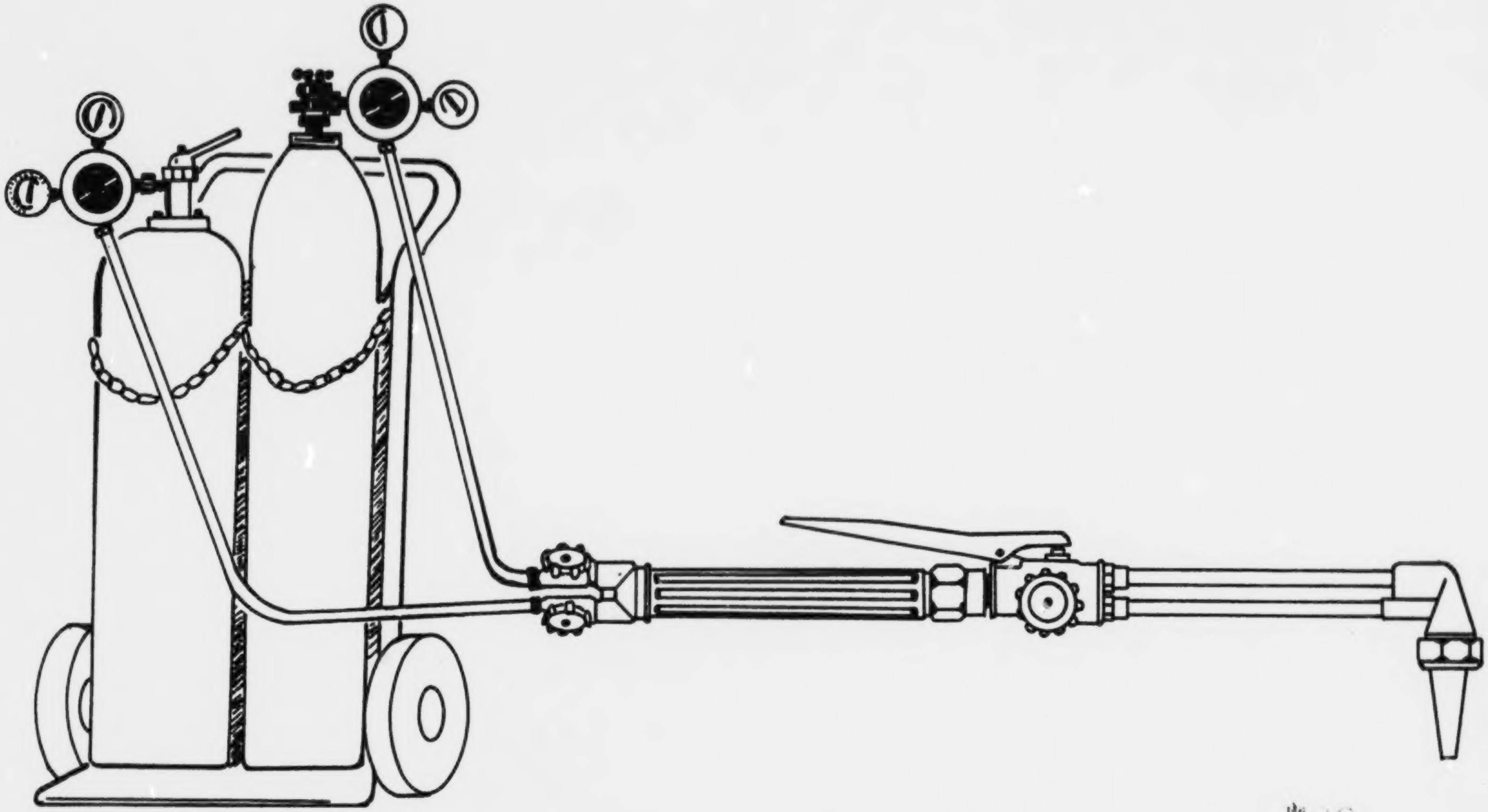
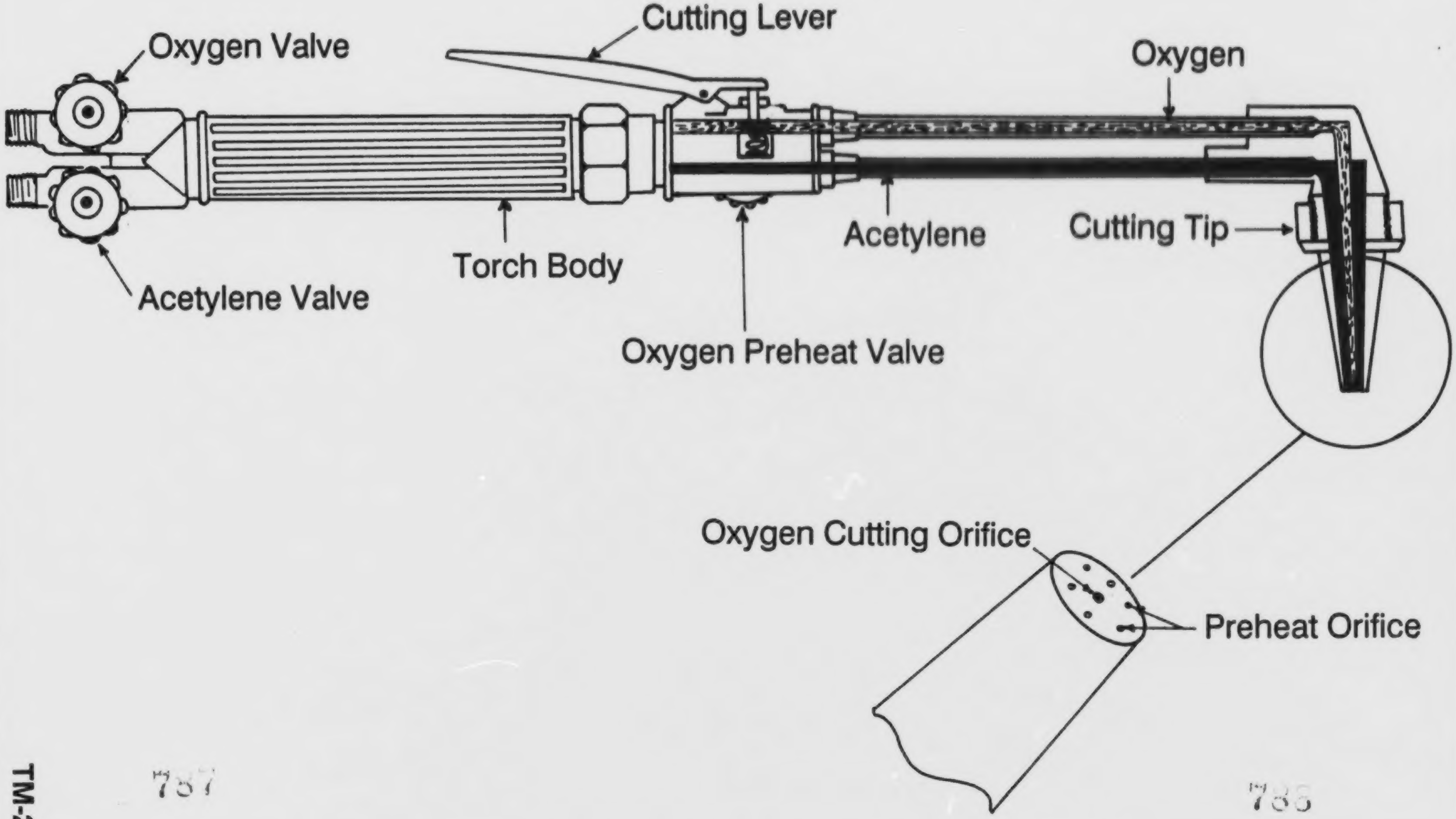
Cutting Torch Equipment



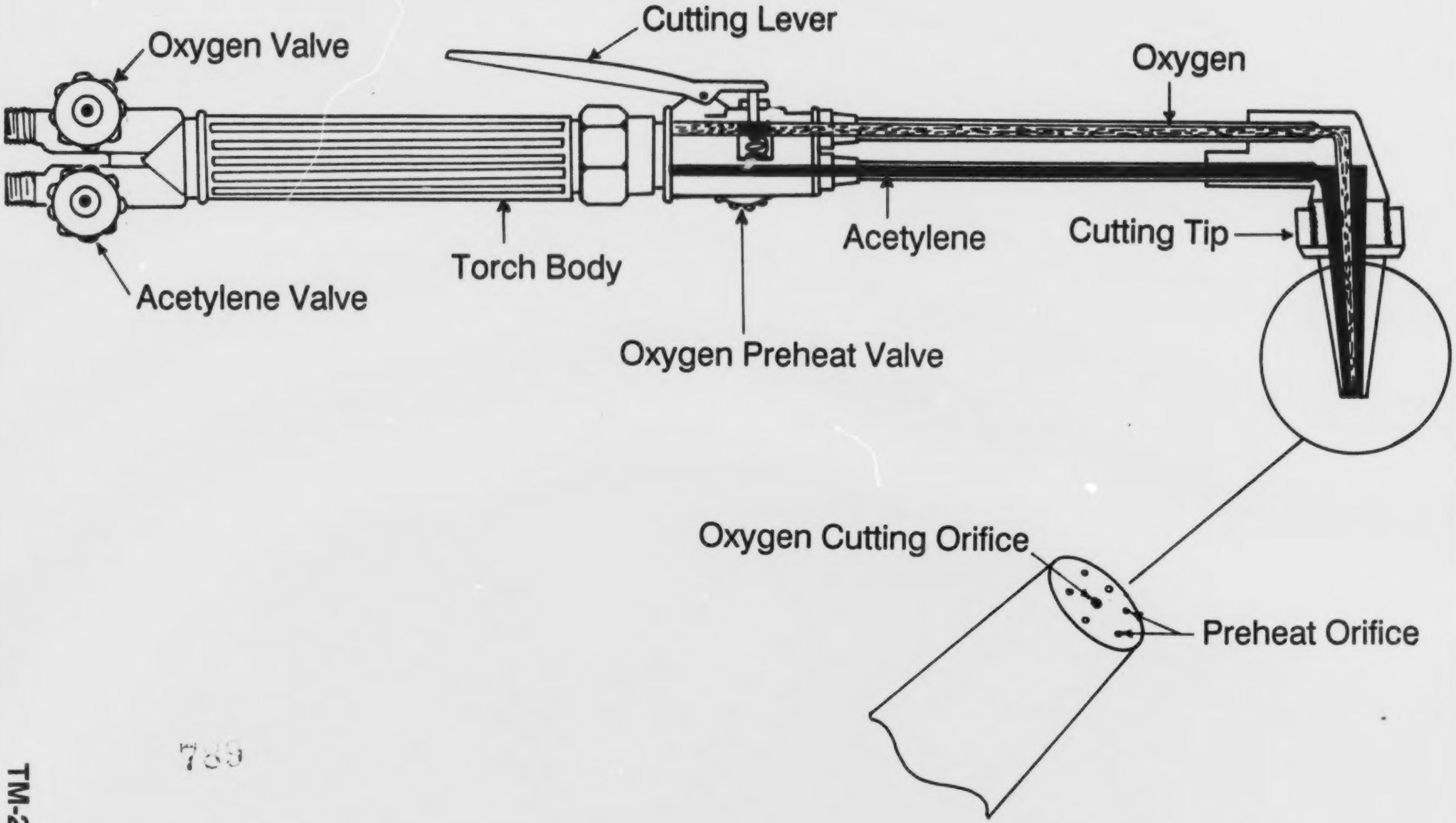
TM-1

Cutting Torches


Cutting Lever
Oxygen Valve
Oxygen
Cutting Tip
Acetylene
Torch Body
Acetylene Valve
Oxygen Preheat Valve
Oxygen Cutting Orifice
Preheat Orifice

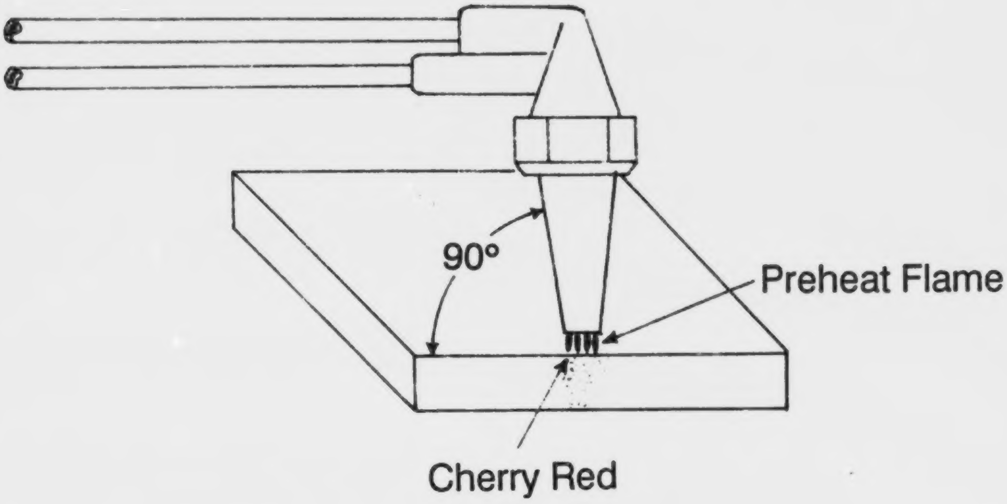
TM-2

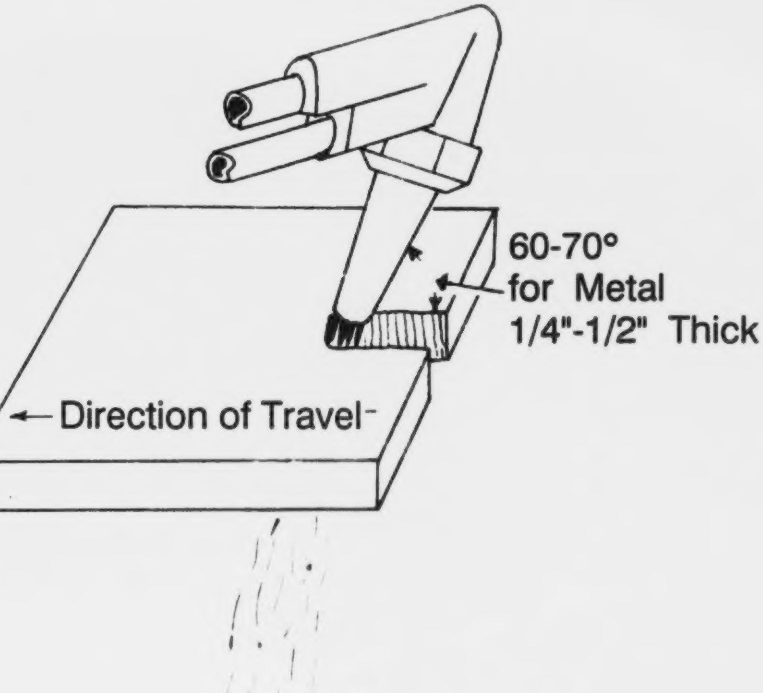
Cutting Torches


Cutting Lever
Oxygen Valve
Oxygen
Cutting Tip
Acetylene
Torch Body
Acetylene Valve
Oxygen Preheat Valve
Oxygen Cutting Orifice
Preheat Orifice

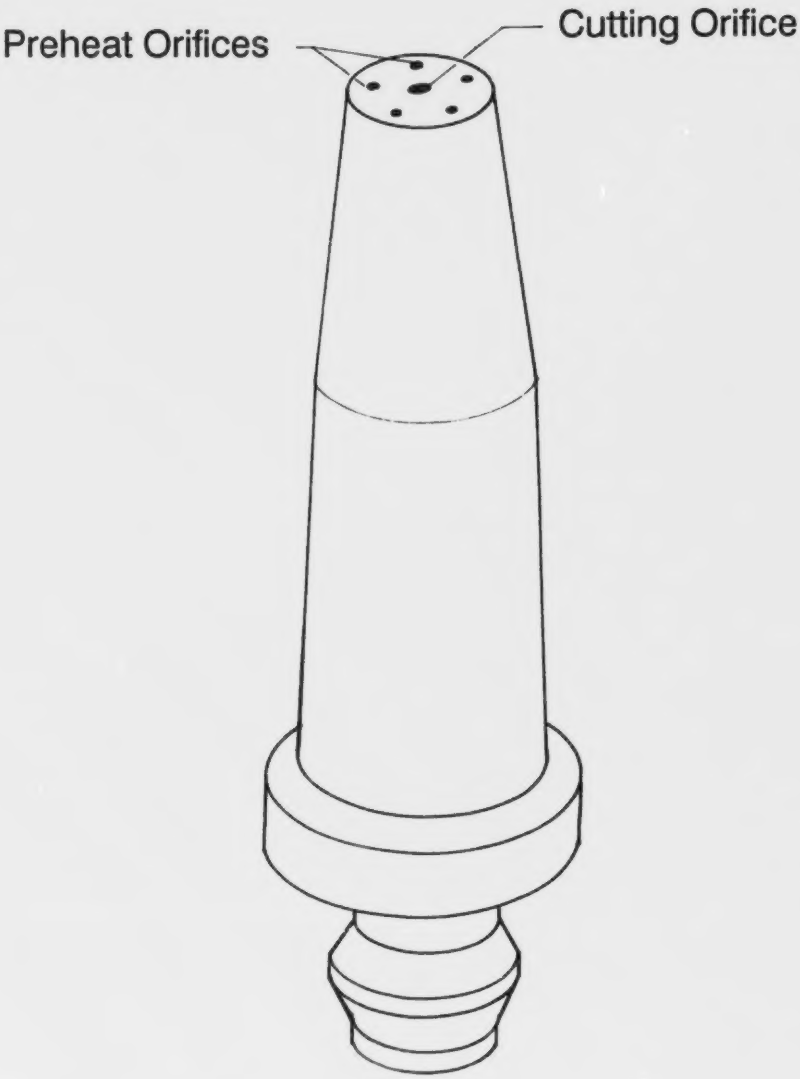
TM-2

Positioning The Torch

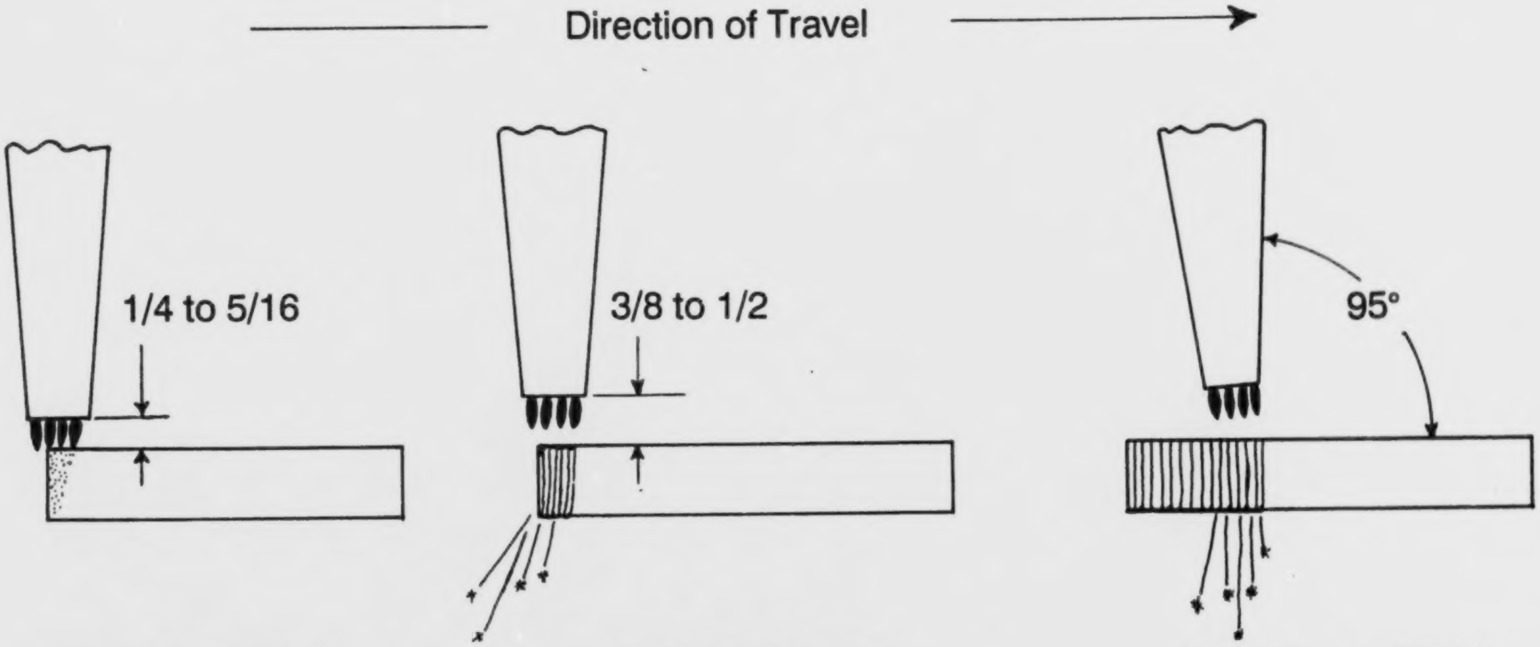

90°
Preheat Flame
Cherry Red


60-70°
for Metal
1/4"-1/2" Thick
Direction of Travel

The Cutting Tip


Preheat Orifices
Cutting Orifice

Steps In Cutting


Direction of Travel
1/4 to 5/16
3/8 to 1/2
95°

Preheat Edge of Metal

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Raise Torch and Depress Cutting Lever

Lean Torch Slightly And Begin Travel

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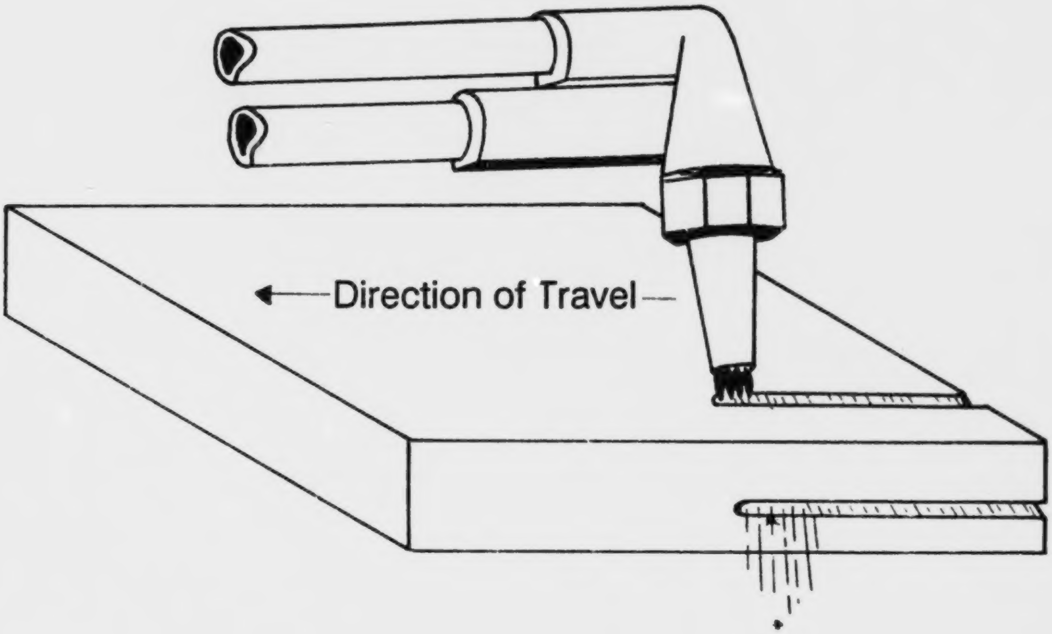
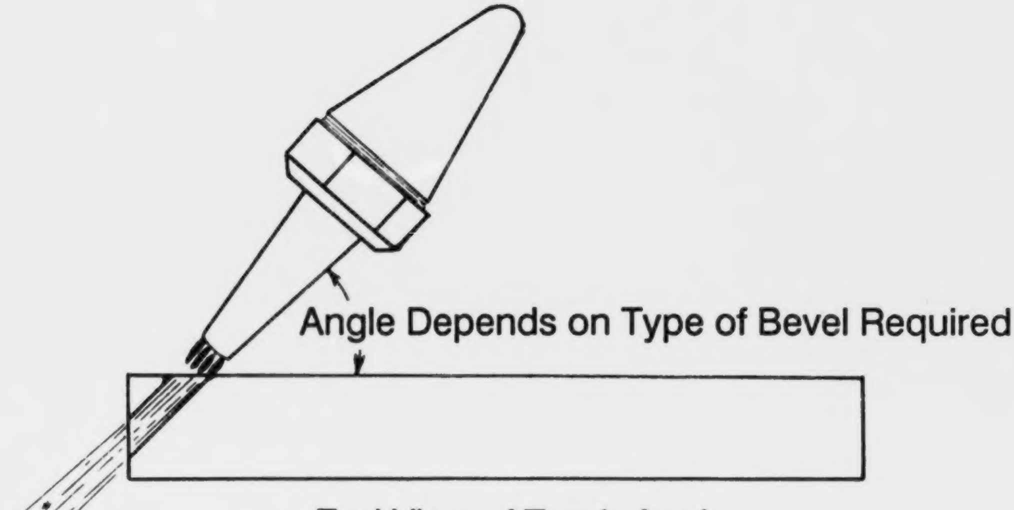
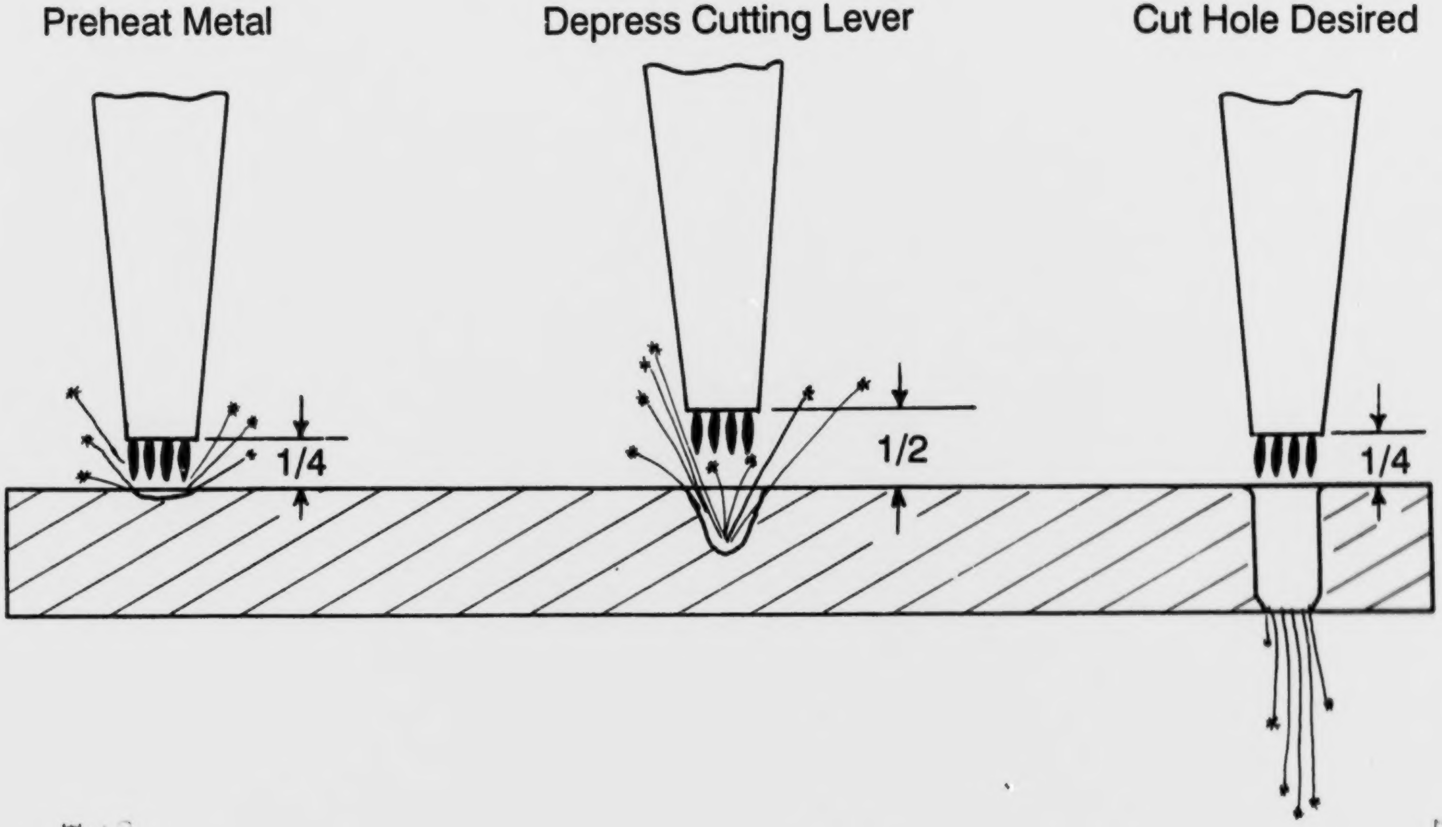
Cutting A Bevel


Direction of Travel


Angle Depends on Type of Bevel Required

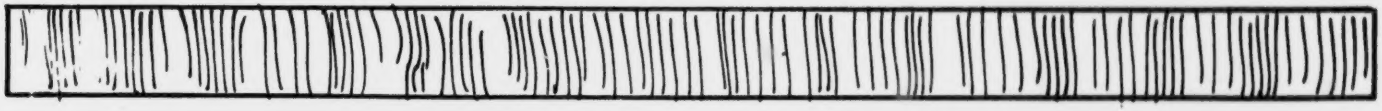
End View of Torch Angle

Piercing A Hole

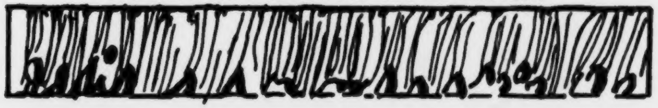

Preheat Metal
Depress Cutting Lever
Cut Hole Desired
1/4
1/2
1/4

TM-7

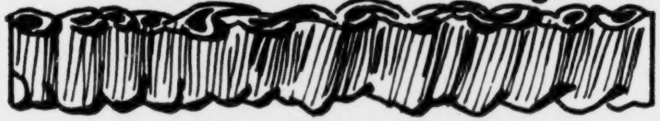
Examples Of Poor Torch Cuts



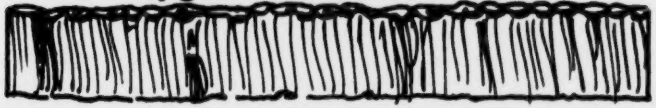
A Good Cut



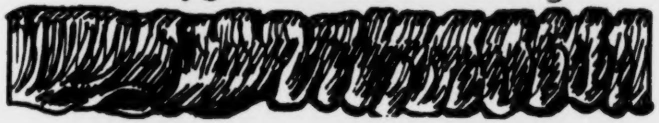
Preheat Flames Too Small



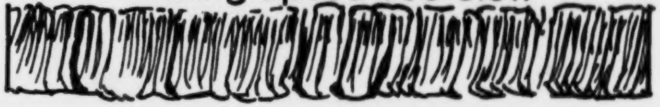
Preheat Flames Too Long



Oxygen Pressure Too Low

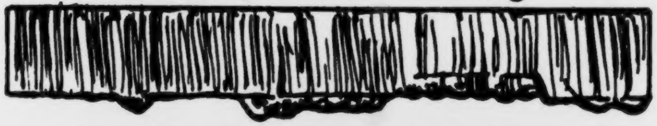


Oxygen Pressure Too High

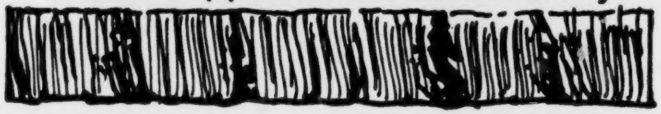


Cutting Speed Too Slow

Cutting Speed Too Fast



Unsteady Torch Handling

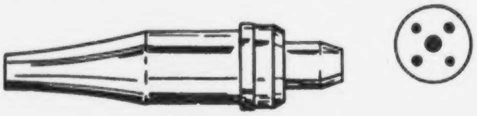


Cut Stopped and Started Poorly

Cutting Tip Selection Chart

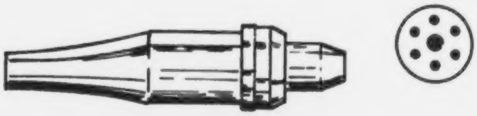
Thickness of Steel	1/4"	1/2"	3/8"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"	6"
Common Tip Size	0	1	1	2	2	2	3	3	4	5	5	6	6
Gage Pressure Oxygen P.S.I.	30	30	40	40	50	60	45	50	50	45	60	50	55
Gage Pressure Acetylene P.S.I.	3	3	3	3	3	3	3	3	3	4	4	5	5
Speed in inches per minutes	20	19	17	15	14	13	12	10	9	8	7	6	5
Oxygen Consumption Cu. Ft. per hour	50	75	90	120	140	160	185	200	250	310	385	460	495
Acetylene Consumption Cu. Ft. per hour	9	12	12	14	14	14	16	16	17	22	22	28	28
Approximate width of kerf in inches	.075	.095	.095	.110	.110	.110	.130	.130	.145	.165	.165	.190	.190
Cutting Orifice Cleaning Drill size	64	57	57	55	55	55	53	53	50	47	47	42	42
Preheat Orifice Cleaning Drill	71	69	69	68	68	68	66	66	65	63	63	61	61

Typical Cutting Tips and Orifices



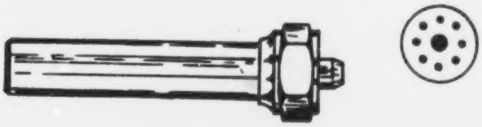
Acetylene

Light Preheat, Light Cutting



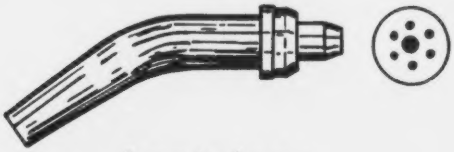
Acetylene

Medium Preheat, Light Cutting



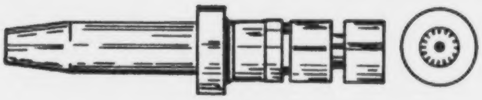
Acetylene

Heavy Preheat, Heavy Cutting



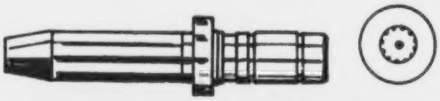
Acetylene

Medium Preheat, Gouging



Propane

General Purpose



Natural Gas (Methane)

General Purpose

ASSIGNMENT SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Using the Cutting Torch

TOPIC: The Cutting Torch

DIRECTIONS: Read and answer the following questions in the spaces provided.

1. Match the following terms and definitions:

_____a. Oxidizing

_____b. Tip cleaner

_____c. Preheat time

_____d. Oxides

_____e. Drag lines

_____f. Backfire

_____g. Preheat orifice

_____h. Flame cutting

_____i. Slag

1. A sudden burning of the flame back into the torch as the flame goes out with a pop
2. The process by which steel is removed by heating to the melting point and then rapidly oxidizing it with pure oxygen under pressure
3. Combining of oxygen with steel forming a scale or slag
4. The deposits or oxides left after a cut has been made
5. Rust, corrosion, scale coating, or slag
6. The slot where metal was removed in the form of oxides during the cutting process
7. The lines formed on the metal being cut which appear to be lagging behind at the bottom of the cut
8. A fire burning inside the torch
9. Heating the metal at the starting point of a cut to its melting temperature

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_____j. Kerf

10. The part of the cutting tip which mixes the gases to produce a preheat flame

_____k. Flashback

11. A tool with different sized wires to remove carbon deposits from welding tips

2. Identify the parts of the torch body and cutting attachment by placing the correct number to the left of the letter.

   ______ a. Torch body

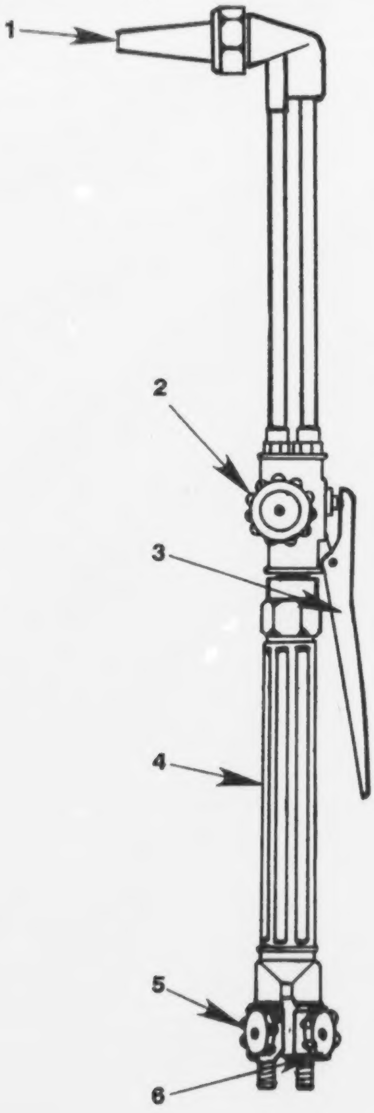
   ______ b. Cutting tip

   ______ c. Acetylene torch valve

   ______ d. Cutting lever

   ______ e. Oxygen torch valve

   ______ f. Oxygen preheat valve



3. Point out the hazards of hot slag by answering YES or NO to each of the following statements

______ a. Hot slag gives off radiation

______ b. Hot slag will cause burns to the body

______ c. Hot slag takes days to cool

______ d. Slag will burn hoses

______ e. Hot slag will cause concrete to explode

______ f. Hot slag causes fire on clothing

4. Place a "√" in front of any of the following phrases that best identify the causes of backfires.

______ a. Moisture in the air

______ b. Acetylene or oxygen pressure too low

______ c. Cutting tip nut loose

______ d. Overheating the cutting tip

______ e. Improper weave pattern

______ f. Faulty O-rings

______ g. Rust or dirt on metal being welded

5. Determine the results of a backfire by circling the correct answer in each of the following:

   a. The flame burns inside the tip (for hours, for a short time).

   b. There is usually a loud (pop, explosion).

   c. The flame sometimes (gets bigger, goes out).

   d. The flame may continue to burn (normally, out of control).

6. Point out the results of a flashback by circling the correct answer in each of the following:

   a. A fire is burning (around the tip, inside the torch).

   b. The flame seems (to go out, to get larger).

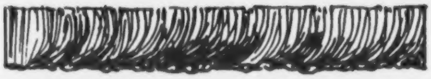
   c. A squealing or hissing noise means the flashback is (over, beginning).

d. Torch starts (smoking, shaking) and getting (hot, cold).

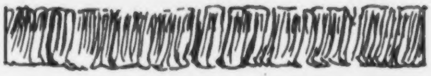
e. The torch will (quit burning, burn in half) if a flashback continues.

7. Determine the reasons for poor torch cuts by placing the letter of the reason next to the correct torch cut illustration.

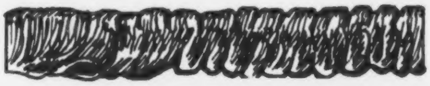
_____ a.



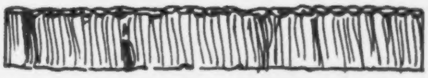
_____ b.



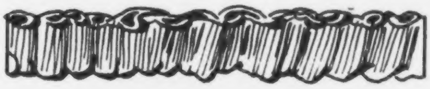
_____ c.



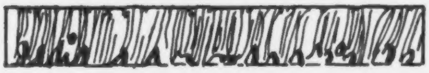
_____ d.



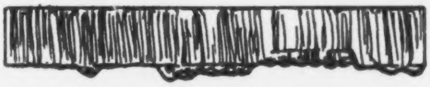
_____ e.



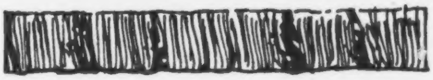
_____ f.



_____ g.



_____ h.



1. Oxygen pressure too high
2. Unsteady torch movement
3. Cutting speed fast
4. Cutting speed slow
5. Cut stopped and started poorly
6. Oxygen pressure too low
7. Preheat flames too long
8. Preheat flames too small

8. Match the terms on the right with their correct definitions.

_____a. A condition where the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

_____b. The cut made by a cutting torch

_____c. The porous oxidized residue left after oxyacetylene cutting

1. Kerf
2. Slag
3. Drag line

9. Complete a list of characteristics of a good cut by inserting the word(s) that best completes each statement.

a. Edge is ______________________________

b. Drag lines are ____________________ and ____________________

c. No adhering ______________________ at bottom edge of cut

10. Select the true statements concerning the characteristics of oxyacetylene cutting by placing a "T" in the appropriate blanks.

______ a. Oxyacetylene cutting units are readily portable and can be taken to the work as opposed to having to bring the work to the cutting equipment.

______ b. Oxyacetylene cutting equipment is relatively inexpensive when compared to the cost of other cutting procedures.

______ c. Oxyacetylene cutting can be accomplished quickly, but is probably the slowest method of cutting thicker metals or cutting irregular or odd shapes.

______ d. Oxyacetylene cutting, when properly executed, delivers a high-quality cut.

______ e. Oxyacetylene cutting is often done manually, but can be adapted to automatic processes.

JOB SHEET
WELDING

NAME ______________________ **DATE** ______________

UNIT: Using the Cutting Torch

TOPIC: Set up Equipment for Oxyacetylene Cutting

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to set up equipment for oxyacetylene cutting correctly.

TOOLS AND EQUIPMENT:

Oxygen cylinder
Acetylene cylinder
Oxygen regulator
Acetylene regulator
Hoses and check valves
Wrench
Cylinder holder
Torch body with tips
Leak detector
Goggles

GENERAL INSTRUCTIONS: Follow procedures to set up oxyacetylene cutting equipment properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Fasten cylinders in a vertical position.
2. Remove caps from cylinders.
3. Crack valves of each cylinder, then close valves.
4. Connect oxygen regulator to oxygen cylinder.
    a. Turn adjusting screw on regulator counterclockwise until tension on spring is released.
    b. Slowly turn cylinder valve wide open.

5. Connect acetylene regulator to acetylene cylinder.
    a. Turn adjusting screw on regulator counterclockwise until tension on spring is released.
    b. Open cylinder valve ½ to ¾ of a turn.
6. Connect acetylene hose to acetylene check valve and purge hose.
7. Connect oxygen hose to oxygen check valve and purge hose.
8. Connect torch body to oxygen and acetylene hose and close both valves on torch body.
9. Attach cutting attachment to torch body.

    Note: *The tip size is determined by the thickness of metal to be cut and the manufacturer's recommendations.*

10. Close oxygen preheat valve on cutting attachment.
11. Turn adjusting screw on oxygen regulator clockwise until working pressure is reached.
12. Turn adjusting screw on acetylene regulator clockwise until correct working pressure is reached.
13. Test all connections for leaks with leak detector.
14. Have your instructor check your work.
15. Check in tools and equipment, or prepare for next job sheet as directed by your instructor.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Using the Cutting Torch

TOPIC: Turn on, Light, Adjust, and Turn off Oxyacetylene Cutting Torch

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to turn on, light, adjust, and turn off oxyacetylene cutting torch correctly.

TOOLS AND EQUIPMENT:
Oxyacetylene welding unit with cutting torch attached
Protective clothing
Goggles or shield

GENERAL INSTRUCTIONS: Follow procedures to turn on, light, adjust, and turn off oxyacetylene cutting torch properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Start-up

1. Put on oxyacetylene goggles, coveralls, and gloves.
2. Prepare welding unit.
3. Check to make sure all torch and cylinder valves are closed.
4. Put cutting attachment on torch body

   Note: *All valves should be on the same side of the torch.*
5. Slowly open acetylene cylinder valve ¼ round.

6. Regulate the winged adjusting screw until the low pressure gauge reaches 5 PSI.

7. Slowly open the oxygen cylinder valve until pressure has stopped climbing on the high pressure gauge and then open the valve all the way.

8. Regulate the winged adjusting screw until the low pressure oxygen gauge reaches 20 PSI.

Flame adjusting

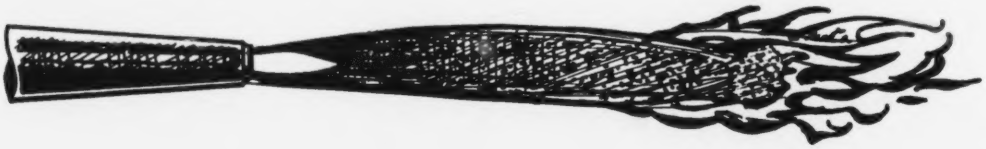
1. Using the flint lighter, light the torch by opening the acetylene torch valve 1/4 turn and striking the lighter in front of the tip.

2. Open acetylene valve until the flame almost quits smoking.

3. Open oxygen valve all the way (leave open).

4. Open the oxygen preheat valve slowly until a neutral flame has been reached.

   Note: *There should be a group of clear inner cones in the flame.*



5. Depress the cutting lever and see if the neutral flame remains.

6. If a feather appears on the inner cone, adjust the oxygen preheat valve until the neutral flame is reached while the lever is depressed.

Shut-down

1. To shut torch off, first close acetylene torch valve.

2. Close oxygen preheat valve.

3. Close acetylene cylinder valve.

4. Open acetylene torch valve until both gauges reach zero.

5. Close acetylene torch valve.

6. Back out the winged adjusting screw until tension or regulator is released.

7. Close oxygen cylinder valve.
8. Open torch oxygen valve until both gauges reach zero.
9. Close oxygen torch valve.
10. Back out the winged adjusting screw until the tension on the oxygen regulator is released.
11. Practice this assignment until you are able to perform easily.
12. Ask your instructor to check the procedure used in lighting and adjusting the cutting torch.
13. Shut down welding unit and roll up hoses.
14. Place the torch and dolly in a secure place.

JOB SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Using the Cutting Torch

TOPIC: Lay Out Lines on a Piece of Metal and Cut with Cutting Torch at 90 Degree Angle

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay out lines on a piece of metal and cut with cutting torch at 90 degree angle correctly.

TOOLS AND EQUIPMENT:

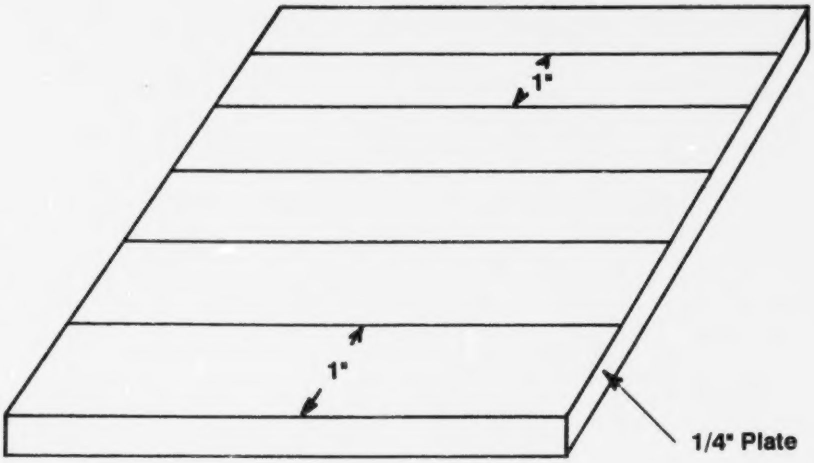
Trysquare
Soapstone
Oxyacetylene welding unit
  with cutting torch attached
Pliers
Cooling vat
Chipping hammer
Tip cleaners
One piece of 1/4-in. steel plate
  (approx. 4 x 6-in.)
Protective clothing
Goggles

GENERAL INSTRUCTIONS: Follow procedures to lay out lines on a piece of metal and cut at 90 degree angle.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety procedures.*

1. Using the trysquare and soapstone, mark off 1-in. spaces along the 6-in. length on the plate.

2. On each of these marks, draw a line across the 4-in. length of the plate with trysquare.



3. Place the plate on the cutting table in position to cut.

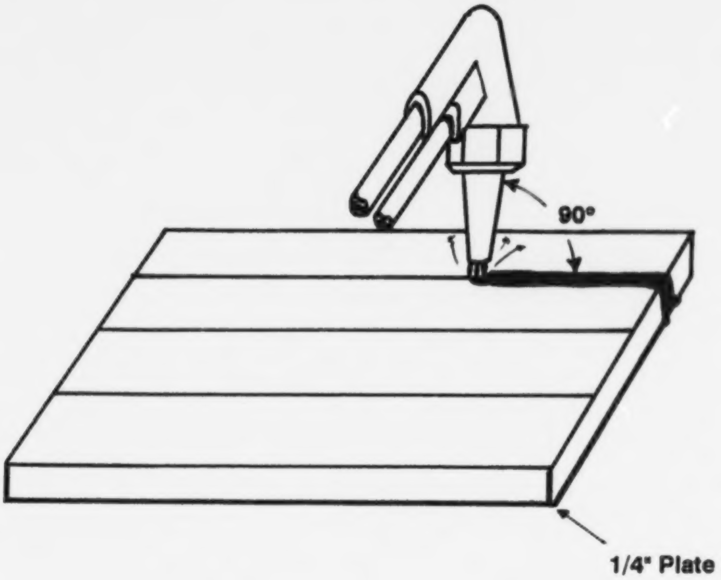
   Note: *Support the plate with fire bricks or scrap metal.*

4. Put on oxyacetylene goggles, coveralls, and gloves.
5. Turn on oxyacetylene welding unit to 5 PSI acetylene and 20 PSI oxygen.
6. Light and adjust torch to a neutral flame.
7. Place the hoses where the hot slag will not fall on them.
8. Hold cutting attachment with left hand and torch body with right hand.

   Note: *Left-handed individuals should reverse this.*

9. Rest arm on table where cutting flame is in position to cut one of the soapstone lines, and at 90 degrees to the plate.
10. Hold the preheat flame with the inner cones 1/16 to 1/8-in. off the plate at the right edge on the line.

11. When the metal reaches its melting point, depress the oxygen cutting lever and move steadily to the left across the plate, keeping the torch the same height.



12. If the torch stops cutting, release oxygen cutting lever.
13. Preheat the edge where the cutting stopped.
14. Slowly depress the oxygen cutting lever and continue cutting.
15. Repeat cutting the soapstone lines on the metal until the process can be easily done.
16. Hold metal with pliers while cooling in a water vat.
17. Continue this operation until you are able to make a good clean cut.
18. Ask the instructor to observe your cutting operation.
19. Shut down welding unit and roll up hoses.
20. Place torch and welding dolly in a secure place.

JOB SHEET
WELDING

NAME ________________________________ **DATE** ____________________

UNIT: Using the Cutting Torch

TOPIC: Cut a Hole in Steel Plate

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to cut a hole in a steel plate correctly.

TOOLS AND EQUIPMENT:

Trysquare
Soapstone
Oxyacetylene welding unit
Cutting table
Welder's gloves
Goggles
Pliers
Cooling vat
Wire brush
Cutting attachment (with No. 0 cutting tip)
Spark lighter
Coveralls
Chipping hammer
Tip cleaners
Mild steel plate, 1/4 x 4 x 6-in.

GENERAL INSTRUCTIONS: Follow procedures to cut a hole in a steel plate properly.

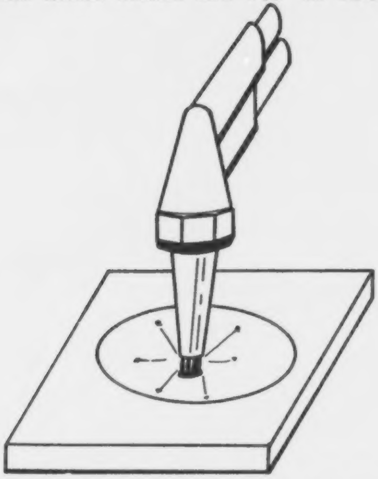
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Lay out a circle, with a radius of about 1-in., on the plate metal with the soapstone and lay the plate on the cutting table in position to cut.
2. Put on oxyacetylene goggles, coveralls, and gloves.
3. Turn on oxyacetylene welding unit (5 PSI acetylene, 20 PSI oxygen).
4. Light and adjust torch to a neutral flame.

5. Move hoses behind operator.

6. Holding torch with both hands, move into a comfortable position with the torch in the center of the circle on the plate.

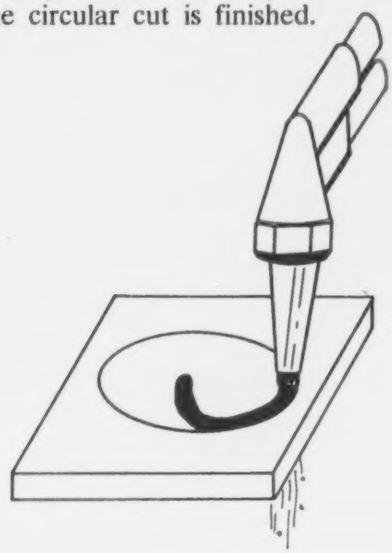
7. Hold torch where the inner cones are 1/16- to 1/8-in. above the center of the circle.



8. When the metal reaches its melting point, depress the cutting lever and raise the torch about 1/2-in.

9. As the molten metal forms, move the torch slightly to one side until the cut pierces the plate.

10. Move the torch steadily over to the soapstone marks and follow the inside edge of the line until the circular cut is finished.



11. Repeat this process until it can be easily done.
12. Hold plate with pliers and dip in cooling vat.
13. Turn off oxyacetylene welding unit and roll up hoses.
14. Remove slag with chipping hammer.
15. Have instructor check work.
16. Clean tools and materials and put in proper place.

IV-3-JS-6

JOB SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Using the Cutting Torch

TOPIC: Set up and Cut a Pipe Bevel by Hand

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(B)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to set up and cut a pipe bevel correctly by hand.

TOOLS AND EQUIPMENT:

- Oxyacetylene cutting unit with tip
- Welding goggles
- Welding gloves
- Spark lighter
- Pliers
- Wraparound
- Soapstone marker
- Center punch (optional)
- Pipe with 3/16-in. wall thickness
- Tip wrench, if required
- File
- Wire brush

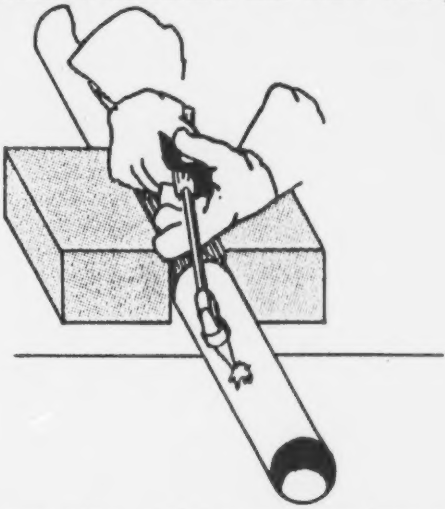
GENERAL INSTRUCTIONS: Follow procedures to set up and cut a pipe bevel by hand properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Inspect area to make sure it is free and clear of flammable materials and well ventilated, and note location of nearest fire extinguisher.

2. Select tip according to wall thickness of pipe, place on torch, and tighten finger tight or with wrench according to manufacturer's recommendations.

3. Place pipe on a suitable work surface and brace with pieces of fire brick so pipe can be rotated.



4. Place wraparound over pipe, make sure it overlaps to give a straight line, then mark the cutting line with soapstone.

   Note: *When preheating the cutting line, the soapstone may burn off, and you may want to mark the cutting line at a few points with a center punch.*

5. Put on welding gloves and goggles.

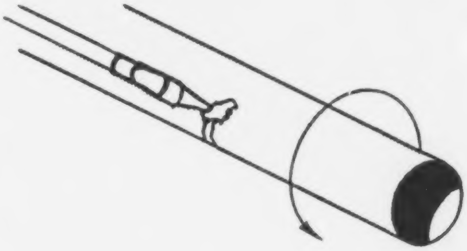
6. Light and adjust torch to neutral flame.

7. Start preheating on the sidewall of the pipe at a point slightly down from the top of the pipe, about 10 or 11 o'clock.

8. Angle the tip of the torch at the starting point so that it will make a cut of 35 degrees through the pipe wall.

9. Move the torch down until the inner flame is about 1/6 to 1/8-in. from the pipe surface and heat a spot about the size of a dime until it turns a bright, cherry red.

10. Turn on oxygen cutting valve slowly, cut for a few inches to the left (if you're right-handed), then stop and rotate the pipe to the left.



11. Restart cut by preheating as required, and keep making short cuts to the left while rotating the pipe until the cut is complete.

12. Close oxygen cutting valve.

13. Turn torch off.

14. Use file to clean slag from inside the pipe and rough edges from the bevel, then clean with a wire brush.

15. Have your instructor check your work.

16. Continue cutting other bevels as directed by your instructor.

17. Shut down equipment, check in tools and materials, or prepare for next job sheet as directed by your instructor.

STUDENT INFORMATION SHEET
WELDING

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Shielded Metal Arc Welding

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)

UNIT OBJECTIVE: After completing this unit, the student(s) will be able to identify welders, welding equipment, types of welds, types of joints, different electrodes, the welding positions used in arc welding and proper safety.

SPECIFIC OBJECTIVE: After completing this information sheet, the student(s) will be able to use welding equipment, make welds, and understand welding terminology and use it correctly.

BASIC ACADEMIC SKILLS APPLICATION: *Basic academic skills used with shielded metal arc welding include oral and written communications, application of mathematical principles, and science.*

Shielded Metal Arc Welding

Welding is playing an important role in the expansion and production of industries. Welding has become one of the main ways to fabricate and repair metal products.

The Arc Welding Process

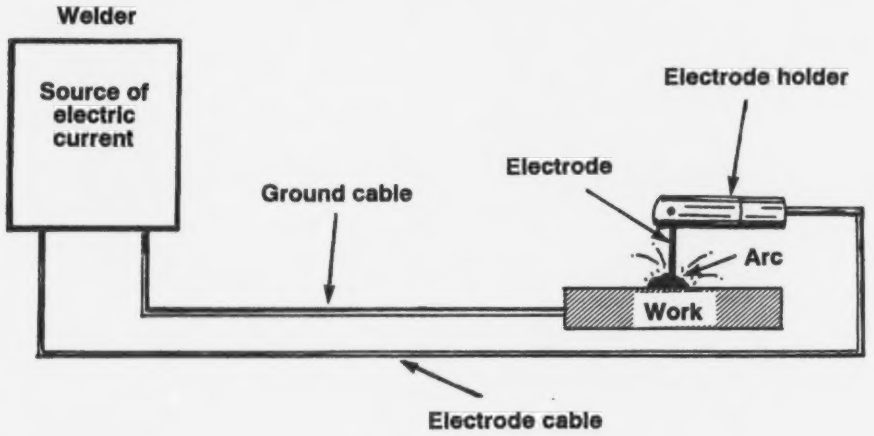
1. The work to be welded is connected on one side by an electric circuit and on the other side to the electrode.
2. The two parts of the electrical circuit are brought together and then separated slightly.
3. The electric current jumps the gap, causing a continuous spark referred to as an arc.
4. The high temperature of this arc melts the metal, forming a puddle.

821

5. The electrode also melts and adds metal to the puddle.

6. When the arc is moved or stopped, the melted metal will become solid.

   Note: *The melting of the metal is controlled by varying the amount of electric current which flows across the arc and by changing the diameter of the electrode.*



Hazards

Note: *Before starting arc welding, you should be aware of the personal dangers involved.*

1. The high temperature of the arc

2. The hot metal which can cause severe burns

3. The two kinds of rays given off by the arc

   Note: *Both types of rays cannot be seen by the naked eye. These rays may cause sunburn on human skin and they can cause severe damage to the eyes in a short time.*

Terms and Definitions

AC (Alternating Current) welder is a unit for welding in which the current changes direction 120 times a second.

Amperage is the measurement for electric current used during welding.

Arc is the flow of electric current from the tip of the electrode to the metal being welded.

Arc length is the distance from the end of the electrode to the base metal being welded.

AWS is the American Welding Society.

Base metal is the metal to be welded.

Crater is the recessed area at the end of a weld.

DC (Direct Current) welder is a unit for welding in which the current travels in one direction only.

Deposited metal is the buildup of metal from the electrode on the weld.

Electrode is a bare or flux-coated rod that is melted into the metal being welded by heat from an electric arc.

Filler metal is a metal added to the weld to produce buildup.

Flux is a chemical coating on the metal electrode that allows the molten metal to fuse to the metal being welded and keeps out impurities and oxygen during welding.

Shielded metal arc welding is a welding process that joins metals by heating with an electric arc jumping from a coated electrode to the metal.

The Arc Welder and Equipment

Types of Welders

AC Welder—A transformer-type of welder producing alternating current

DC Welder—A motor or engine-driven generator producing direct current

AC-DC Welder—A transformer rectifier producing either type of current

> **Note:** *A rectifier is a device placed on AC welder to change the current to DC.*

Welding Machine Adjustments

Current setting (amperage)

1. Increase amperage to produce more heat
2. Decrease amperage to produce less heat

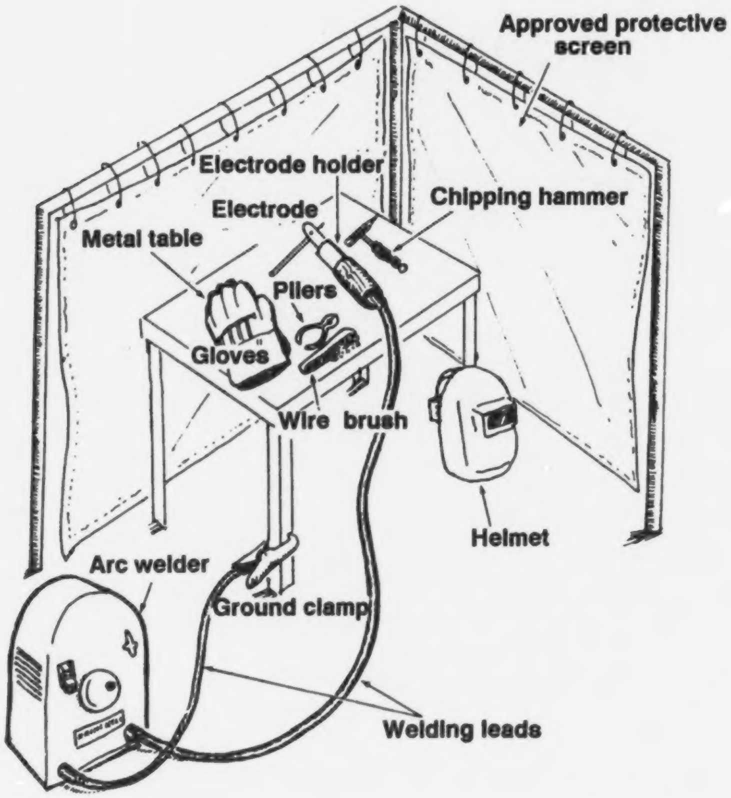
Polarity (DC Welders only)

1. Reverse polarity allows current to flow from base metal to electrode.
2. Straight polarity allows current to flow from electrode to base metal.

Special Uses for the Arc Welder

1. Cutting using special electrodes
2. Hole piercing
3. Gouging or removing metal
4. Beveling metal edges

Arc Welding Equipment

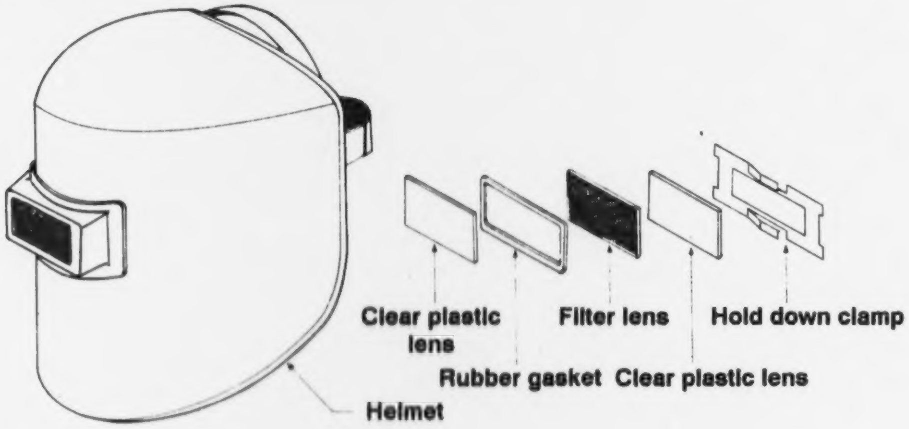

Approved protective screen
Electrode holder
Electrode
Chipping hammer
Metal table
Pliers
Gloves
Wire brush
Helmet
Arc welder
Ground clamp
Welding leads

Welding Lens Assembly

A. Filter lens (#10 lens is recommended)

B. Clear plastic or glass

Example:



Arc Welding Safety

There are many hazards that one must deal with when welding. The first rule to learn before welding is: To take care of yourself and the people around you. Listed below are many of the specific ways to handle the hazardous areas found in welding.

Preventing Electrical Shock

- Properly ground the arc welder.
- Keep the welder in a cool, **dry** location.
- Do not leave cables where they may be damaged by other equipment or machinery.
- When welding, **DO NOT** stand on wet surfaces or in water.
- Use electrode holders that are well-insulated and free from cracks.
- Wear leather gloves that are in good condition.

Protection From Radiation

- The face and eyes should be covered with an arc welding helmet or shield.
- Any exposed skin surface should be covered to prevent burns from the ultraviolet and infrared rays.

- A **verbal warning** should be given to **all persons** in the area before striking an arc.
- Examine the helmet for cracks that will allow light to enter.
- Replace any cracked helmet lens.
- **DO NOT** wear oxyacetylene goggles when arc welding.

Protection From Sparks and Slag

- Wear high-topped leather shoes.
- **DO NOT** wear pants with cuffs.
- Shirts should have long sleeves and button-up collars.
- Wear welding gloves made of leather.
- Leather welding sleeves should be worn when available.
- Leather aprons should be worn when available.
- Safety glasses or goggles should be worn when chipping or cleaning welds.

Eliminating Fumes and Gases

- **DO NOT** weld on galvanized metal because toxic gases are given off.
- Fans or other ventilation should be used to get rid of smoke or gases.
- **DO NOT** weld on containers or metal that have contained chemicals or been painted.

Avoiding Combustible Materials

- Remove all oily rags or greasy materials from the welding area.
- **DO NOT** weld on containers that have held a combustible substance.
- Make sure the floor is non-combustible.
- **DO NOT** weld with matches or butane cigarette lighter in your pocket.

Handling Hot Metals

- Handle hot metal with pliers, not gloves.
- Stand to one side when dropping hot metal into a cooling vat because hot steam will be given off.
- Protect your skin from molten splatter when welding because serious burns can result.

Environmental Safety Requirements

Ventilation is needed because welding activities produce toxic fumes and vapors that are hazardous to breathe. All work stations should be equipped with a ventilation or exhaust system.

Respirators should be used in confined areas where toxic fumes are increased. A welder should wear an air-supplied respirator or a self-contained breathing apparatus, not a filter type mask.

Noise is frequently overlooked. Ear plugs or muffler-type ear protectors should be worn in areas subject to high noise levels.

Lighting should be bright enough to provide good visibility free of glare. Poorly lit work areas will contribute to eye fatigue, irritation, and poor work.

The Electrode

Types of Electrodes

- Mild steel
- Low hydrogen
- Stainless steel
- Cast iron
- Hard surfacing
- Non-ferrous

  Example: *Aluminum*

Electrode Classification

Note: *Refer to a pocket guide for complete specifications.*

A. Standardized coding of the AWS (American Welding Society)

Example: *E 6011*

B. E stands for electrodes

Example: *Ⓔ6011*

C. The first two digits identify the tensile strength of the deposited metal in thousands of pounds per square inch

Example: *E (60) 11 (60 x 1000 = 60,000 psi)*

D. Third digit indicates the welding position for which the electrode is designed

1. A number 1 here indicates all positions

   Example: *E 60①1*

2. A number 2 here indicates flat or horizontal positions only

   Example: *E 70②4*

E. The fourth digit indicates electrical characteristics of the electrode

Example: *E 601①*

Note: *Refer to a pocket guide for other electrode specifications.*

1. Current used
   a. AC
   b. DC straight polarity
   c. DC reverse polarity
2. Type of flux coating
3. Penetration

Electrode Sizes

- Determined by the diameter of the bare metal rod
- Range in size from 1/32 to 5/16-in. in increments of thirty-seconds
- Common size 3/32, 1/8, 5/32, 3/16, 7/32, 1/6, 5/16-in.

Purposes of Flux

- Keeps air out of the molten puddle
- Allows weld to cool more slowly, making the weld stronger
- Removes impurities from weld puddle
- Prevents the arc from moving (or jumping) around on the base metal
- Prevents holes from forming in the weld metal
- Adds alloys to weld metal for strength
- Allows a faster deposit rate of the weld metal

Five Things Needed to Produce a Good Weld

A. Correct electrode size, which depends on:

1. Type, position, and preparation of the joint
2. Ability of the electrode to carry high current without injury to base metal
3. The thickness of the base metal

Approximate Current Setting For Electrode Diameter and Metal Thickness

ELECTRODE DIAMETER	APPROX. METAL THICKNESS SINGLE PASS	CURRENT SETTING MIN.	MAX.
1/16	1/16	20	40
3/32	3/32	30	80
1/8	1/8-1/4	50	120
5/32	1/8-1/4	75	170
3/16	1/4-3/16	100	210
7/32	1/4-3/16	120	250
1/4	1/4-5/16	160	330
5/16	5/16-3/8	200	420

B. Correct current

1. A current setting too high causes the electrode to melt too fast and the puddle becomes large and irregular.
2. A current setting too low does not produce enough heat to melt the base metal and the weld metal piles up and looks rough.

C. Correct arc length

1. An arc length too long causes the metal to melt off the electrode in large drops.

   Note: *This gives a wide spattered and irregular bead with poor fusion.*

2. An arc length too short causes the electrode to stick to the metal.

D. Correct travel speed

   1. If too fast, the puddle will not form and impurities will be trapped in the weld.

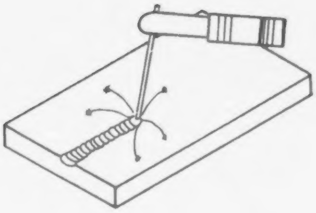
   2. If too slow, the metal picks up; the bead is high and wide.

E. Correct electrode angle

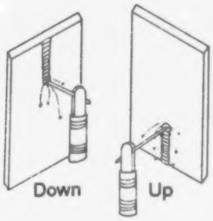
   1. The angle of the electrode affects the strength, penetration, and appearance of the weld joint.

   2. Undercutting is often caused by incorrect electrode angle.

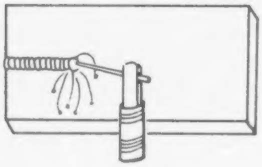
Welding Positions



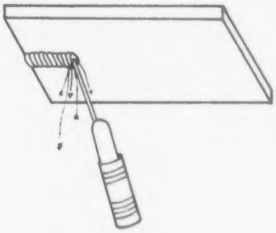
Flat



Vertical

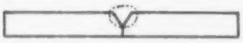


Horizontal

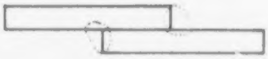


Overhead

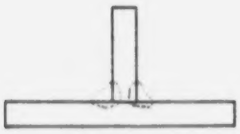
Weld Joints



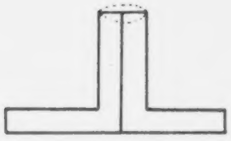
Butt Joint



Lap Joint

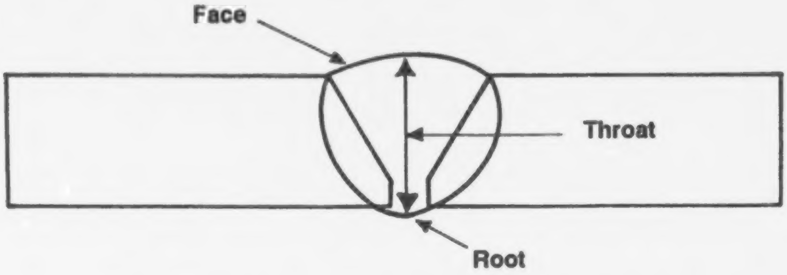


Tee Joint

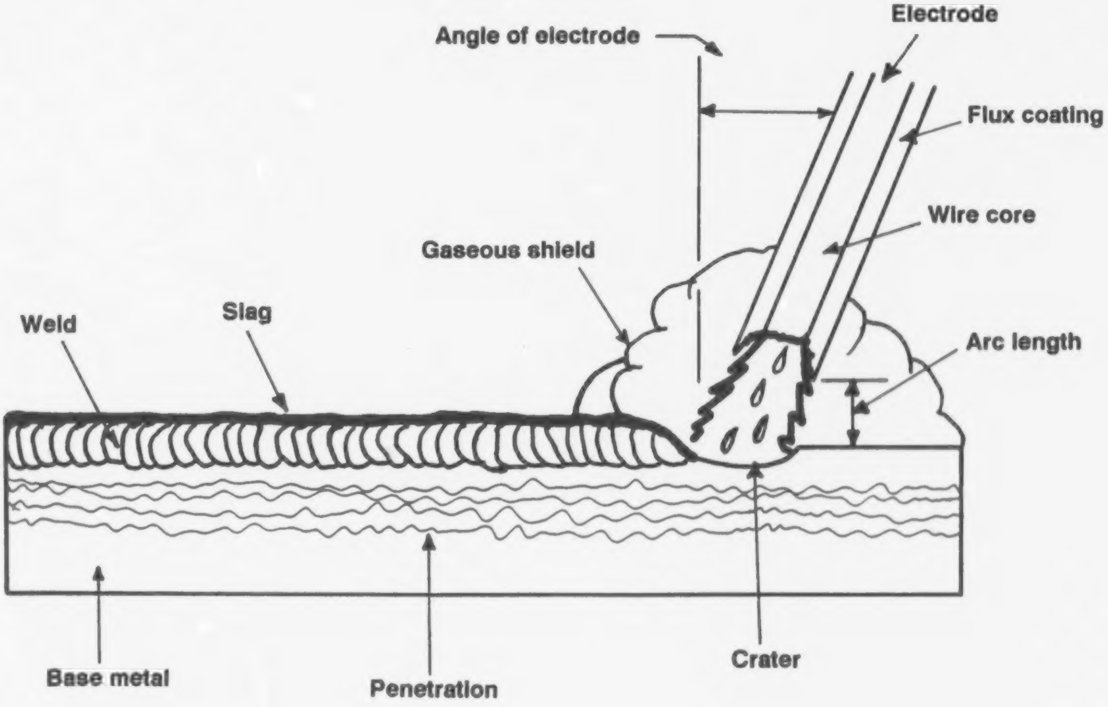


Edge Joint

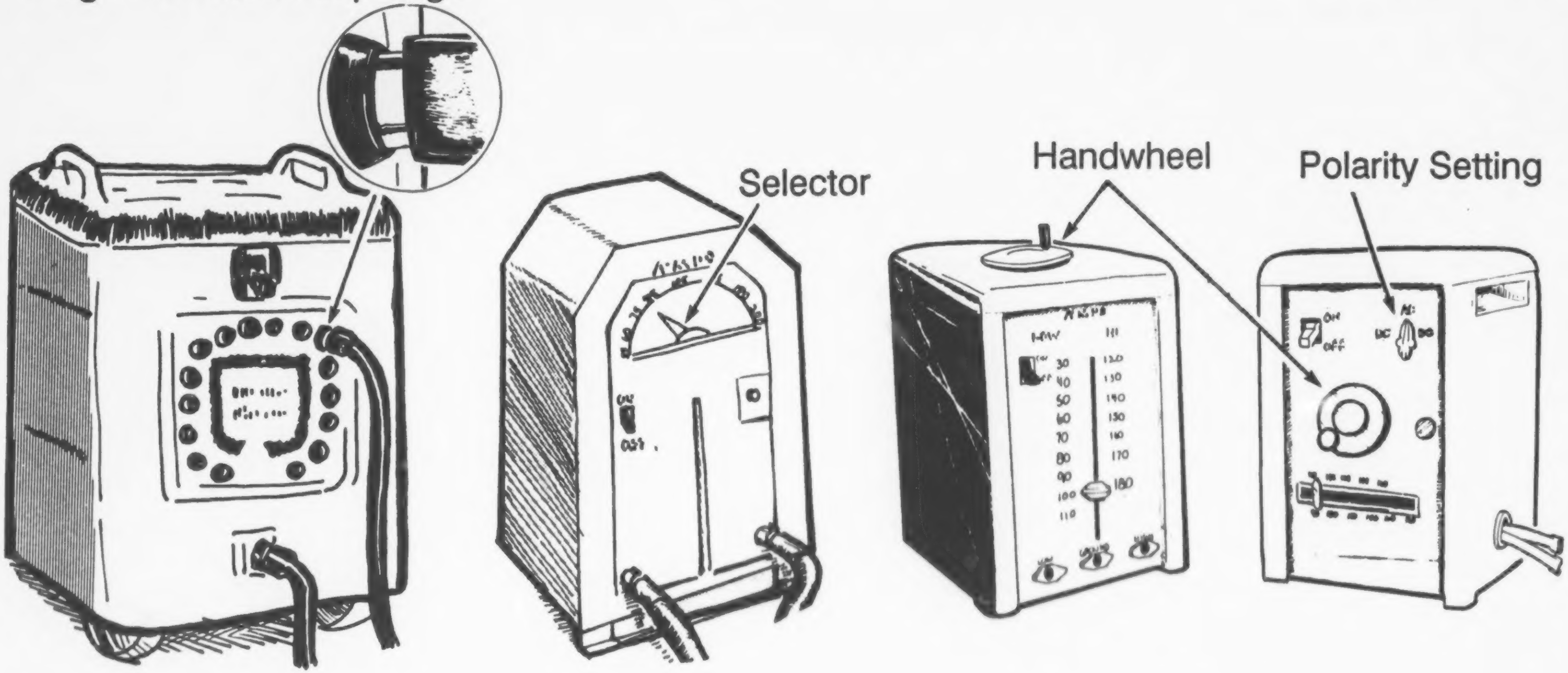
Parts of the Fillet Weld


Face
Throat
Root

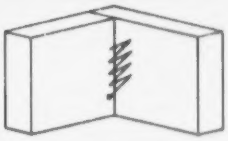
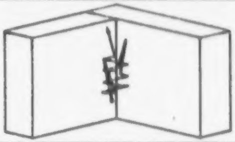
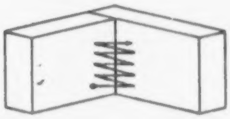
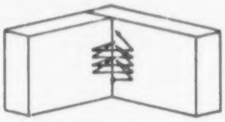
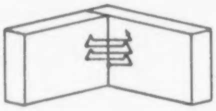
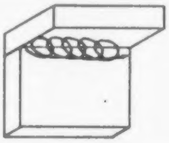
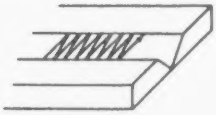
Terms associated with the welding process


Electrode
Angle of electrode
Flux coating
Wire core
Gaseous shield
Weld
Slag
Arc length
Base metal
Penetration
Crater

Type Of Welder Amperage Selectors

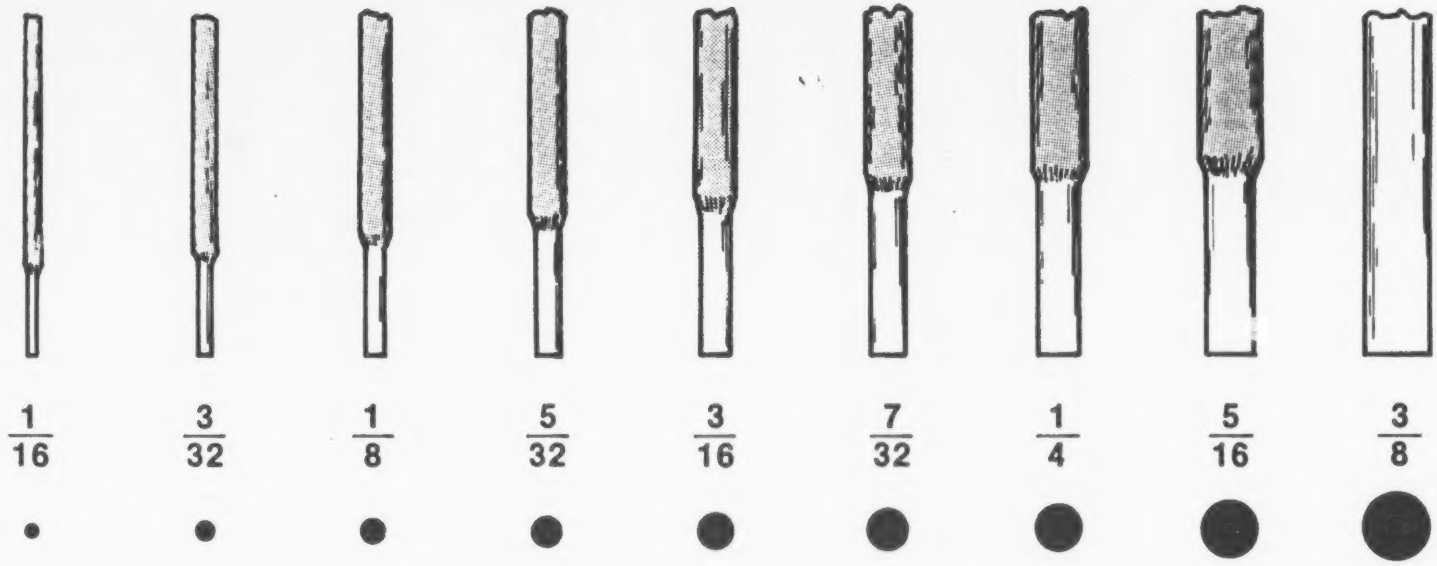

Piug in to Select Amperage
Selector
Handwheel
Polarity Setting
Movable Core

Basic Motions for Electrode Manipulation

Motion	Illustration	Typical Uses
Straight whipping motion		Used with fast-fill electrodes to make stringer beads in all positions and on all types of joints
Whipping motion with slight weave in crater		Used with fast-fill electrodes on the first pass of vertical fillets and V-butts
Vertical side-to-side weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts; sometimes used with fill-freeze and low-hydrogen electrodes for first pass on fillets and V-butts
Triangular weave		Used with fill-freeze and low-hydrogen electrodes to make first pass on vertical fillets and V-butts
Box weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts, and has a distinct pause and slight upward motion at each edge of the weld
Circular motion		Used with all types of electrodes to make overhead welds, and is sometimes used with a slight whip after each circular motion in the crater
Flat side-to-side weave		Used with all electrodes on wide fillets and butts in the flat position

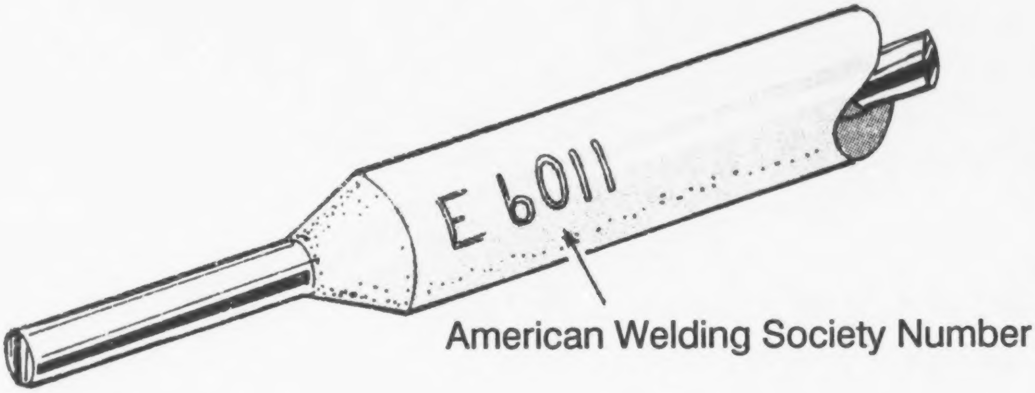
Electrode Sizes

(Actual Sizes)

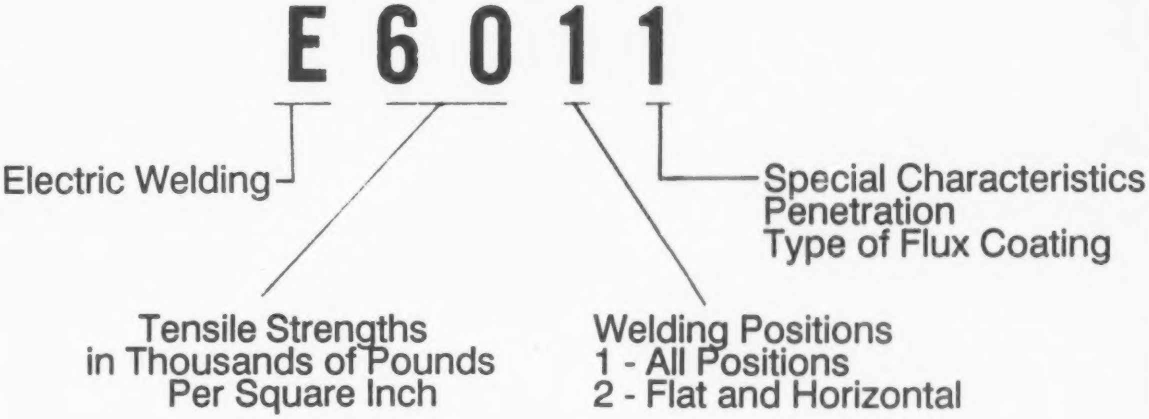


1/16
3/32
1/8
5/32
3/16
7/32
1/4
5/16
3/8

Electrode Coding



American Welding Society Number



E 6 0 1 1

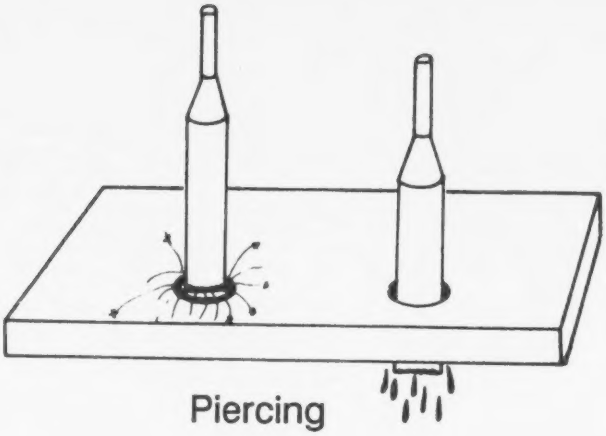
Electric Welding

Tensile Strengths
in Thousands of Pounds
Per Square Inch

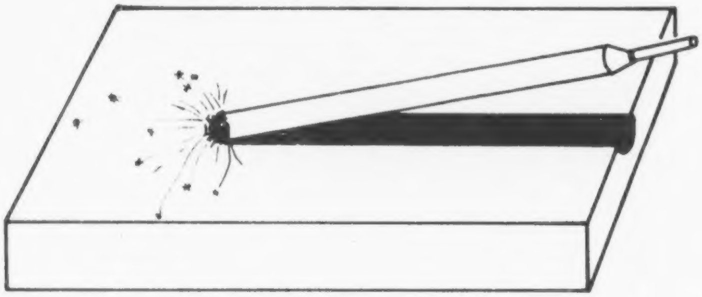
Welding Positions
1 - All Positions
2 - Flat and Horizontal

Special Characteristics
Penetration
Type of Flux Coating

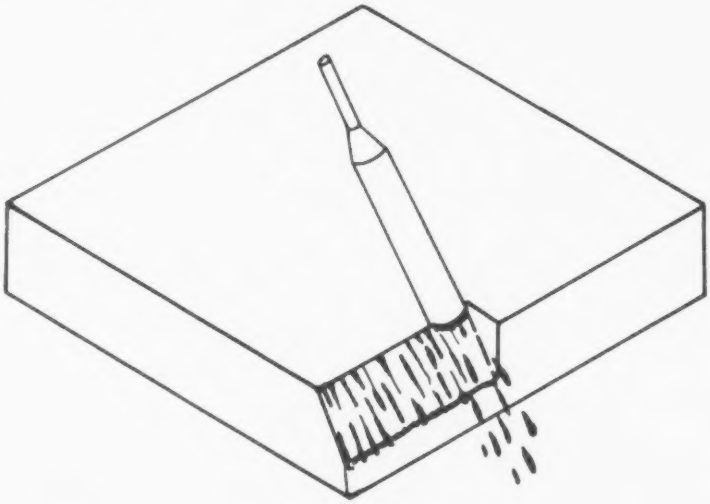
Piercing, Gouging, and Beveling



Piercing

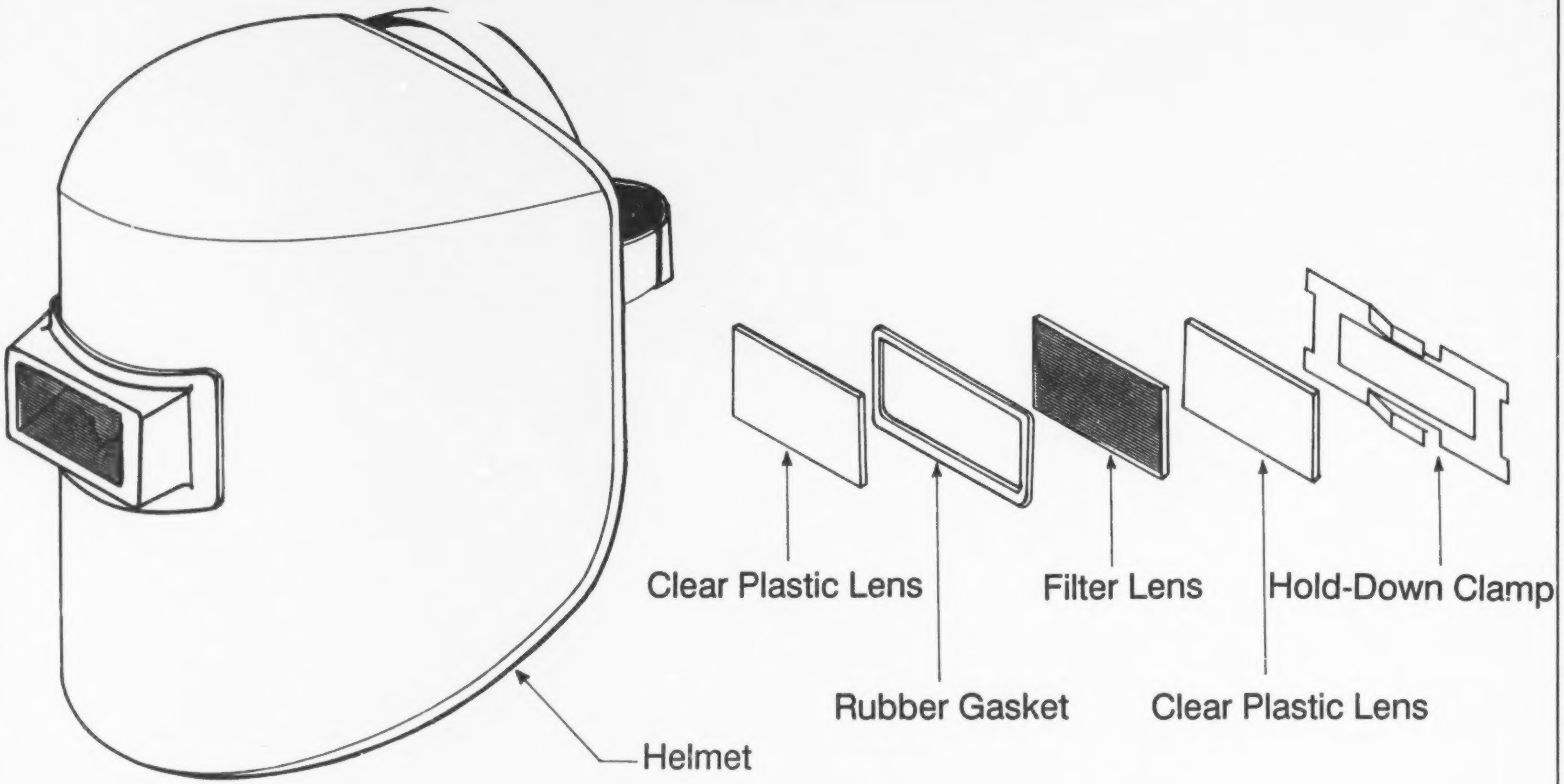


Gouging

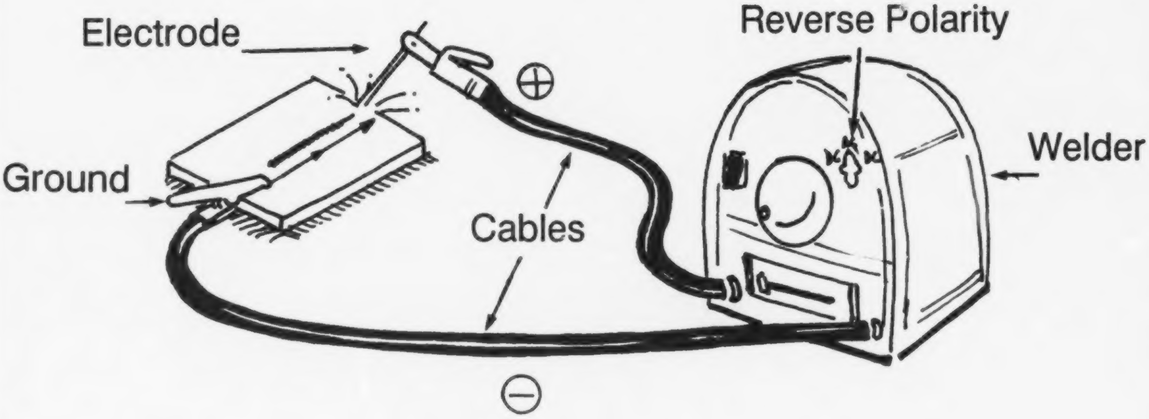


Beveling

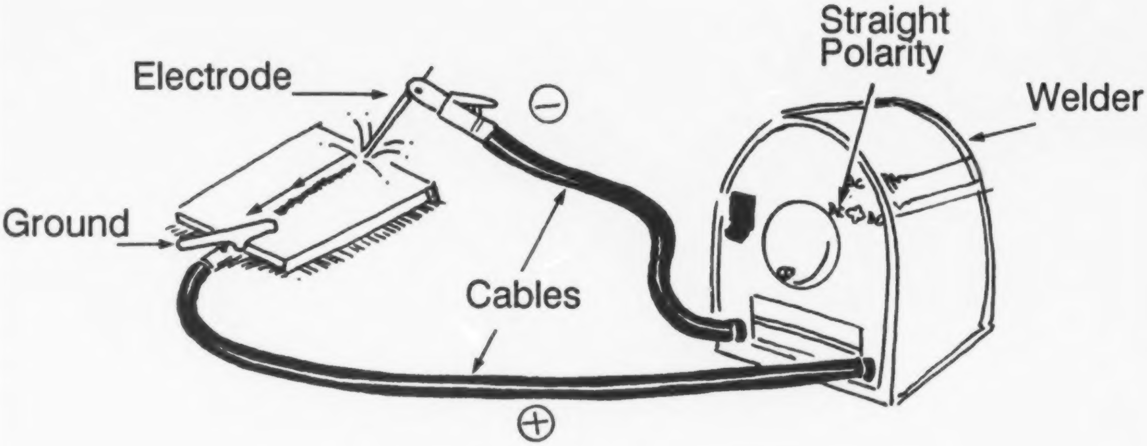
Helmet Lens Installation


Clear Plastic Lens
Rubber Gasket
Filter Lens
Clear Plastic Lens
Hold-Down Clamp
Helmet

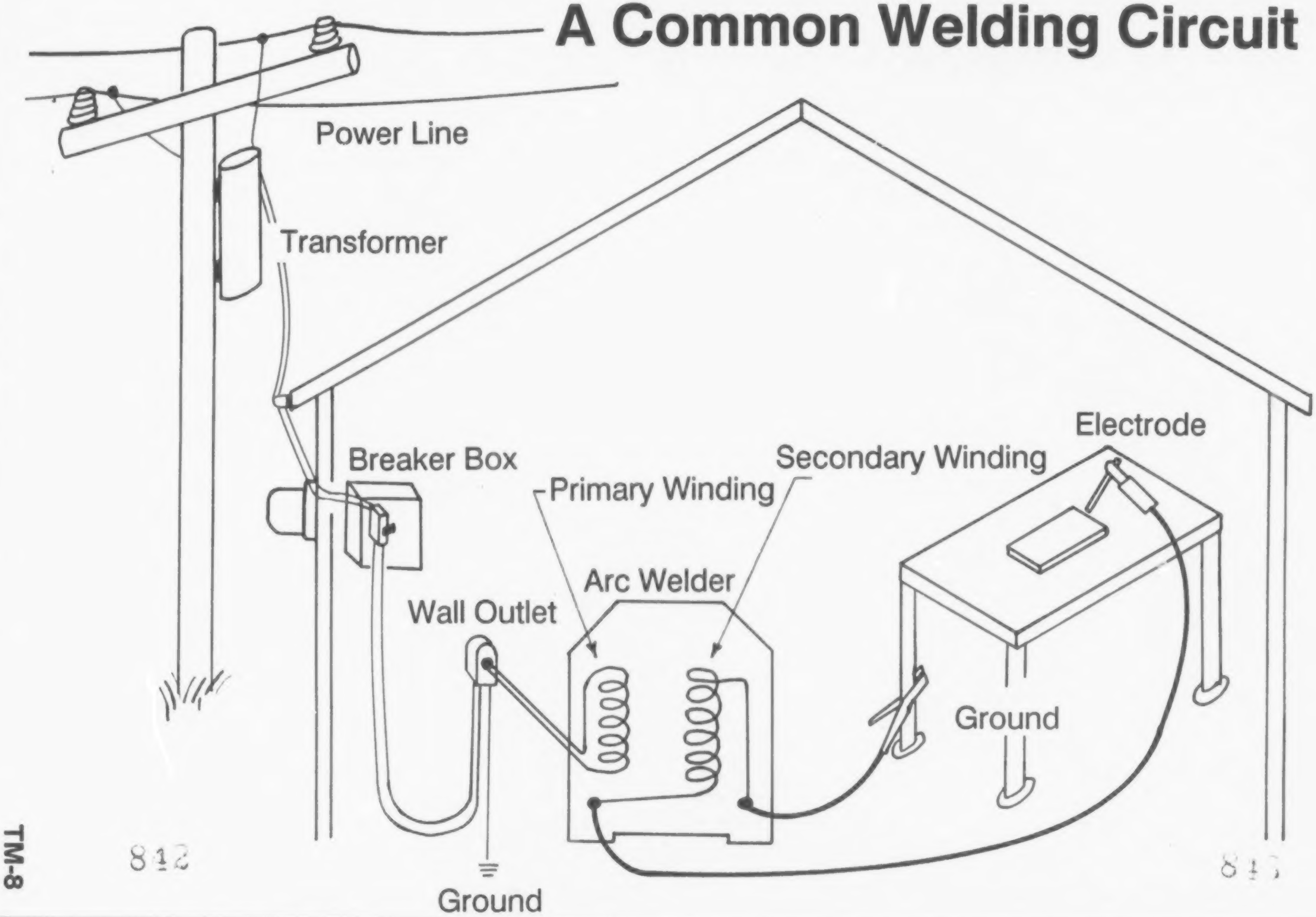
DC Polarity


Electrode
Reverse Polarity
⊕
Welder
Ground
Cables
⊖

Note: Direction of Current

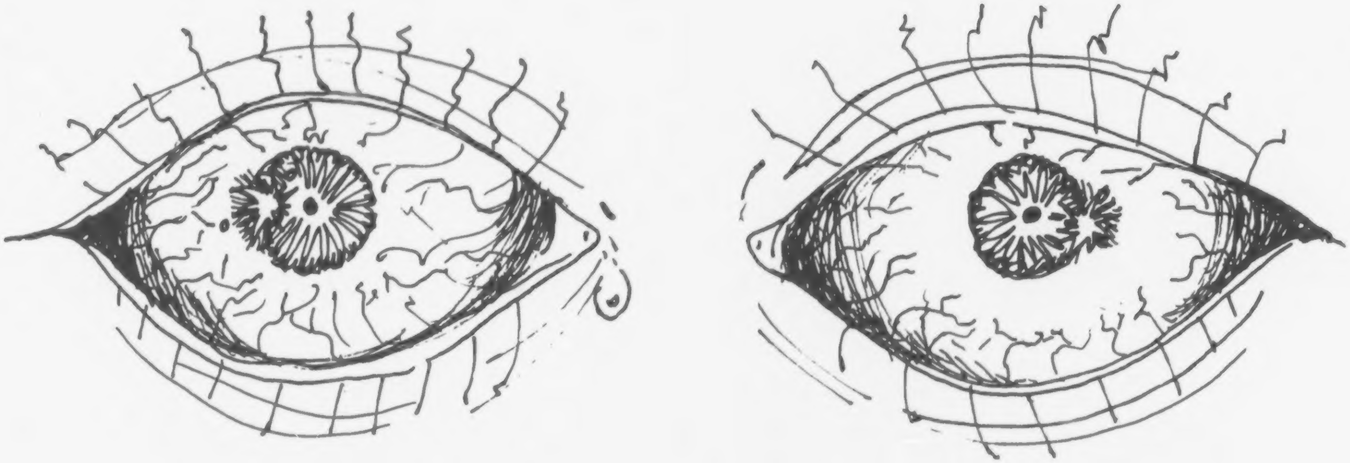

Straight Polarity
Electrode
⊖
Welder
Ground
Cables
⊕

A Common Welding Circuit


Power Line
Transformer
Breaker Box
Primary Winding
Secondary Winding
Electrode
Arc Welder
Wall Outlet
Ground
Ground

TM-8

Eye Protection



Two For One Giveaway
Take One Look At Welding Arc
Give Two Eyes Away

TM-9

844

845

Suggested Current Settings For Electrodes

ELECTRODE DIAMETER	3/32	1/8	5/32	3/16	7/32	1/4	5/16
METAL THICKNESS	3/32	1/8–1/4	1/8–1/4	1/4 –3/16	1/4 3/16	1/4–5/16	5/16–THICKER
6010		75-130	90-175	140-225	200-175	250-325	280-400
6011	40-75	75-120	90-160	120-200	150-260	180-300	
6012	55-80	80-130	120-180	180-250	210-280	250-315	320-410
6013	65-100	90-140	140-200	200-260	225-300	250-350	320-450
6014		110-160	150-225	200-280	260-340	315-425	370-500
6015	70-100	95-155	120-200	160-280	190-310	230-360	375-475
6016	70-100	95-155	120-280	160-280	190-310	230-360	375-475
6018	70-100	95-155	120-200	160-280	190-310	230-360	375-475
6020		100-140	120-180	175-250	200-325	250-400	350-450
6024	65-120	115-175	180-240	240-300	300-380	350-450	450-600
6027			190-240	250-300	300-380	350-380	475-600

TM-10

ASSIGNMENT SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Shielded Metal Arc Welding

DIRECTIONS: Read and answer the following questions in the spaces provided.

1. Explain the arc welding process by writing the number of the word(s) that best complete(s) each statement in the blank provided.

   a. The work to be welded is connected to one side of an electric circuit and the __________ to the other side.

      1. ground clamp
      2. electrode
      3. welding lead
      4. welding torch

   b. To produce an arc for welding, the two parts of the electrical circuit are brought together and then __________.

      1. jerked apart
      2. allowed to stick
      3. separated slightly

c. The electric current jumps the gap from the electrode to the base metal, causing a continuous spark referred to as ____________.

1. an arc
2. bright lights
3. party lights
4. northern lights

d. The high temperature of the arc causes the metal to melt, forming a ___________.

1. mess
2. spatter
3. puddle
4. hole

e. When the welding process is stopped, the melted metal ________.

1. becomes solid
2. becomes rusted
3. disappears because the light has gone out

2. Point out the hazards of arc welding by placing a "√" in front of each.

_____ a. The high temperature of the arc

_____ b. Severe burns caused by hot metal

_____ c. Harmful rays given off by the welding arc

_____ d. The travel to and from your home

3. Match the following terms associated with arc welding to the definition by writing the number of each term in the correct blank on the left.

_____a. A welding process that joins metals by heating them with an electric arc jumping from a coated electrode to the metal

_____b. The flow of electric current from the tip of the electrode to the metal being welded

_____c. A bare or flux-coated electrode that is melted into the metal being welded, using heat from an electric arc

_____d. A chemical coating on the electrode that allows the molten metal to fuse to the metal being welded, and keeps out impurities

_____e. The metal being welded

_____f. Metal added to the weld to produce buildup

_____g. The buildup of metal from the electrode on the weld

_____h. The recessed area at the end of a weld

_____i. Distance from the end of the electrode to the base metal being welded

_____j. A unit for welding in which current changes direction 120 times per second

_____k. A unit for welding in which the current travels in one direction only

_____l. The measurement for electric current

_____m. American Welding Society

1. AC (Alternating current) welder
2. DC (Direct current) welder
3. Crater
4. Base metal
5. AWS
6. Shielded metal arc welding
7. Flux
8. Electrode
9. Amperage
10. Arc
11. Deposited metal
12. Filler metal
13. Arc length

4. Identify three types of arc welders by filling in the correct term in each blank from the list below.

______________ a. A transformer-type of welder producing alternat-current

______________ b. A motor or engine-driven generator producing direct current

______________ c. A transformer rectifier producing either type of current

Carbon-arc welder

AC welder

Oxyacetylene welder

AC-DC welder

DC welder

5. Explain how each of the welding machine adjustments affects the welding process by writing the number of the correct result in the blank on the left.

_____a. Increased amperage

_____b. Decreased amperage

_____c. Reversed polarity

_____d. Straight polarity

1. Allows current to flow from electrode to base metal
2. Produces more heat
3. Allows current to flow from base metal to electrode
4. Produces less heat

6. Select special uses of the arc welder by writing **YES** in front of each of the proper uses.

______ a. Cutting can be done with a special electrode

______ b. Brazing of cast iron

______ c. Hole piercing

______ d. Gouging or removing metal

______ e. Soldering

______ f. Beveling metal edges

7. Identify each of the parts of arc welding equipment by placing the number of each part in the blank to the left of the correct name.

______ a. Arc welder

______ b. Welding helmet

______ c. Leather gloves

______ d. Electrode holder

______ e. Welding leads

______ f. Chipping hammer

______ g. Wire brush

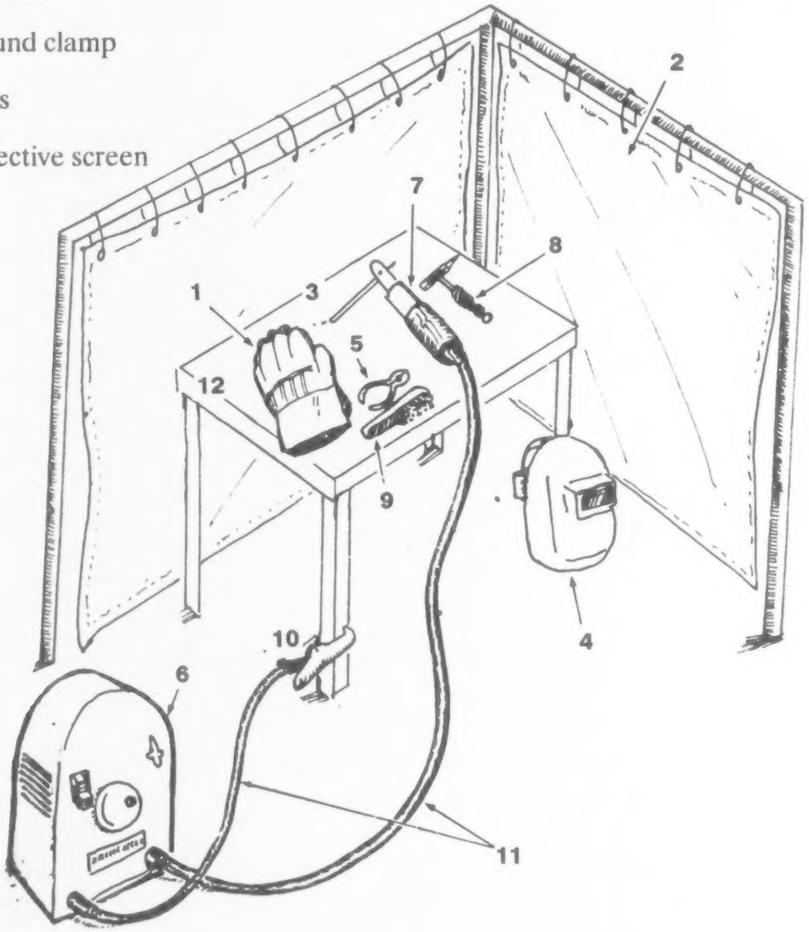
______ h. Metal table

______ i. Electrode

______ j. Ground clamp

______ k. Pliers

______ l. Protective screen



8. Point out the parts of a welding lens assembly by writing each of the following terms in the correct blanks.

Hold-down clamp

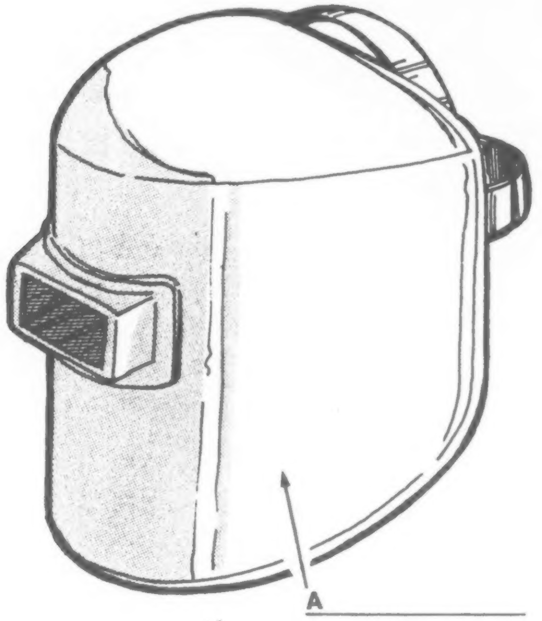
Helmet

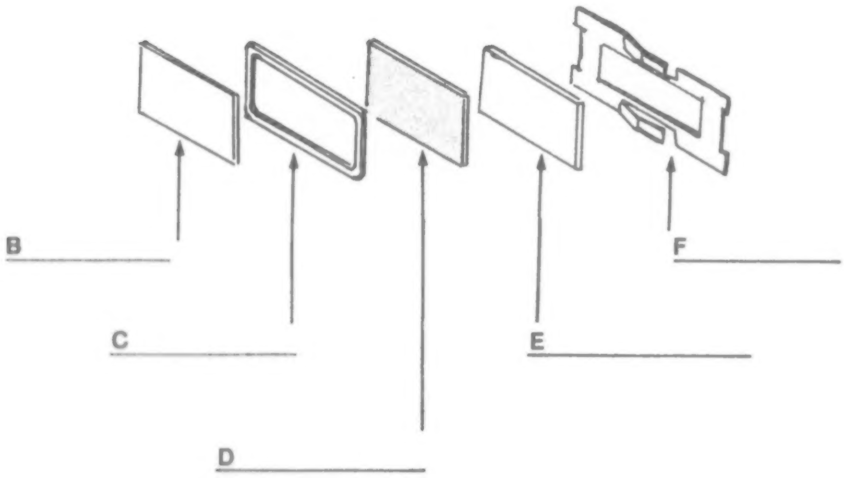
Filter lens

Clear plastic lens

Rubber gasket

Clear plastic lens





Select the proper safety procedures associated with the hazards of arc welding by answering **true** or **false** to each of the statements below.

9. Electrical shock

______ a. The welder does not need to be grounded to be safe.

______ b. The welder should be kept in a cool damp area.

______ c. The welding cables are armored, so it does not hurt to run over them with the welding dolly.

______ d. When welding, do not stand on wet surfaces or in water.

______ e. Use electrode holders as long as possible, even when cracked, because they are expensive.

______ f. Wear leather gloves that are in good condition.

10. Radiation

______ a. The face and eyes should be covered with an arc welding helmet or shield.

______ b. Ultraviolet and infrared rays will only burn the skin of certain people.

______ c. A verbal warning should be given to **all persons** in the area before striking an arc.

______ d. Cracks in a helmet will not be any problem if the lens is good.

______ e. Replace any cracked helmet lens.

______ f. Oxyacetylene goggles may be worn when arc welding.

11. Sparks and slag

______ a. Wear high-topped leather shoes.

______ b. Low-topped shoes may be worn if pants with cuffs are worn.

______ c. Shirts should have long sleeves and button-up collars.

______ d. Wear welding gloves of leather.

______ e. Leather welding sleeves should be worn when available.

______ f. Leather aprons should be worn when available.

______ g. Safety glasses are not necessary if you shield your eyes with your hand when chipping or cleaning welds.

12. Fumes and gases

______ a. There is no danger when welding galvanized metal.

______ b. Fans or adequate ventilation should be provided to remove toxic gases.

______ c. Avoid welding on containers or metals that have contained chemicals or been painted.

______ d. Sparks will not ignite oily rags.

______ e. Do not weld on containers that have held a combustible substance.

______ f. Keep a butane lighter in your pocket for use with the cutting torch.

13. Hot metals

______ a. Handle hot metal with leather gloves.

______ b. Stand to one side when dropping hot metal into a cooling vat because hot steam will be given off.

______ c. Molten metal splatter usually cools quickly and will not burn the skin.

14. Point out the types of welding electrodes by placing a "√" in front of each of the following electrode types.

______ a. Mild steel

______ b. Low hydrogen

______ c. High hydrogen

______ d. Stainless steel

______ e. Brass

______ f. Cast iron

______ g. Hard surfacing

______ h. Copper

______ i. Non-ferrous

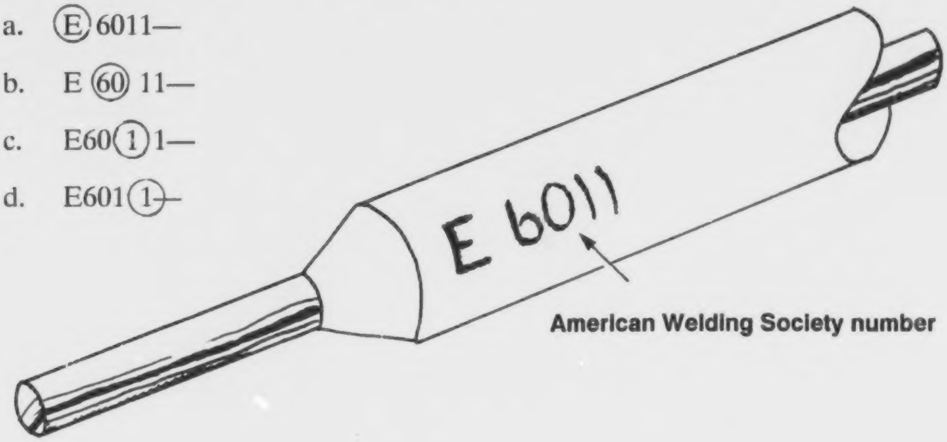
15. Give the meaning for each of the American Welding Society specifications on the electrode below.

a. Ⓔ6011—

b. E (60) 11—

c. E60①1—

d. E601①—



16. Point out the two factors to remember when determining electrode sizes by writing the number of the correct answer in the blank provided.

a. The size is determined by the diameter of _______

   1. the flux coating of the electrode
   2. the metal rod in the electrode

b. The sizes of electrodes range in size from ______________

   1. 1/32 to 5/16-in.
   2. 1/8 to 1/4-in.

17. Determine the purpose of flux by placing a "✓" in front of each correct statement below.

______ a. Mixes air with the molten metal.

______ b. Allows the weld to cool more slowly, making the weld stronger.

______ c. Removes impurities from the weld puddle.

______ d. Prevents the arc from moving around on the metal.

______ e. Prevents holes from forming in the weld metal.

______ f. Adds alloys to the weld metal for strength.

______ g. Allows a faster deposit rate.

18. Point out the things needed to make a good weld by placing a “ √ ” in front of each below.

______ a. Correct electrode size

______ b. Correct current

______ c. Correct electrode length

______ d. Correct arc length

______ e. Correct travel speed

______ f. Correct electrode angle.

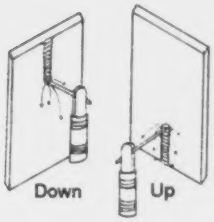
19. Identify each of the following welding positions by labeling each illustration with one of the following terms:

Horizontal

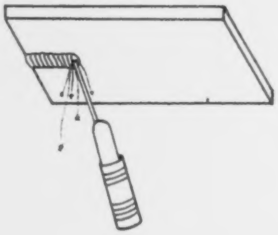
Vertical

Overhead

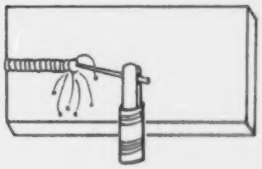
Flat



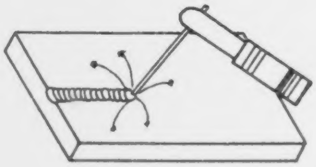
a. ____________________



b. ____________________



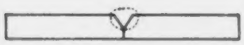
c. ____________________



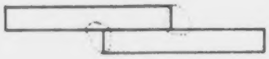
d. ____________________

20. Identify each of the weld joints by labeling each illustration with one of the following terms:

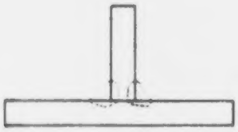
Edge joint	Butt joint
Tee joint	Lap joint



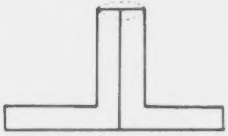
a. ____________________



b. ____________________



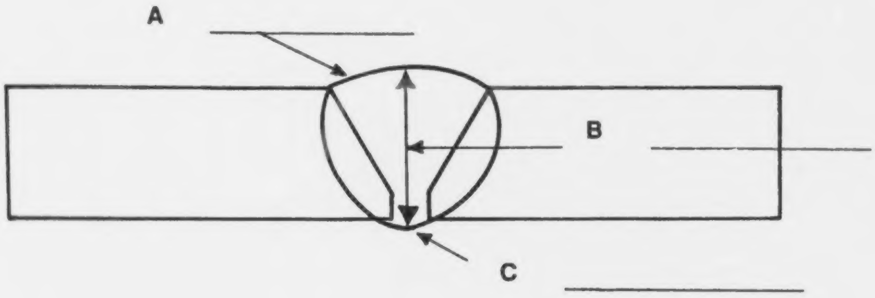
c. ____________________



d. ____________________

21. Identify each of the parts of a fillet weld by labeling each with one of the following terms:

Throat   Root   Face



22. Identify each of the terms associated with the welding process by placing each number to the left of the correct term.

______ a. Weld

______ b. Slag

______ c. Base metal

______ d. Angle of electrode

______ e. Arc length

______ f. Electrode

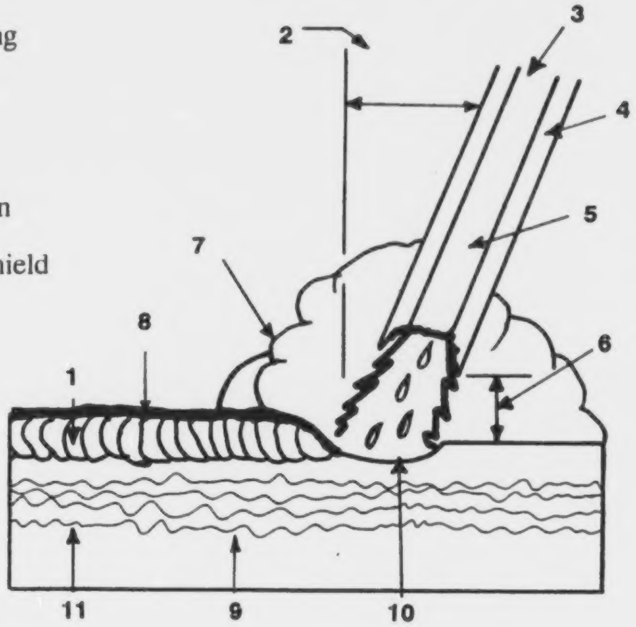
______ g. Flux coating

______ h. Wire core

______ i. Crater

______ j. Penetration

______ k. Gaseous shield



JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Build a Pad on Mild Steel Plate in the Flat Position with E7018

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to build a pad on mild steel plate in the flat position with E7018 correctly.

TOOLS AND EQUIPMENT:

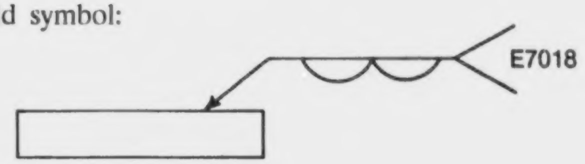
SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Safety glasses

GENERAL INSTRUCTIONS: Follow procedures to build a pad on mild steel plate in the flat position with E7018 properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety procedures.*

Specifications

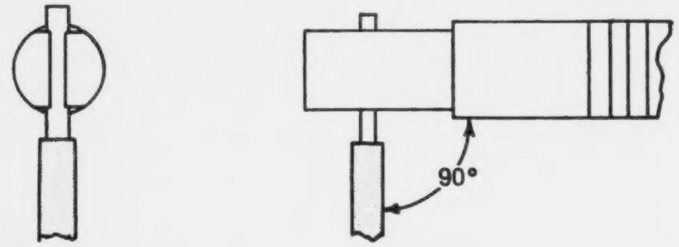
1. Plate and weld symbol:



2. Filler metal and number of beads: E 7018, 1/8-in. or 5/32-in..
3. Electrical characteristics: DC + or AC
4. Position: Flat
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush after each bead.
7. Testing: Visual
8. Technique: Drag
9. References: AWS A2.4-79 (10.2) and AWS B3.0-77 (4.2)

Procedures

1. Place electrode in holder as indicated.

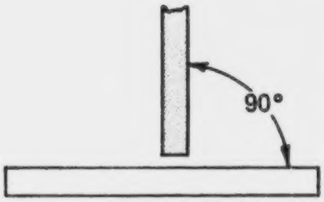


End View

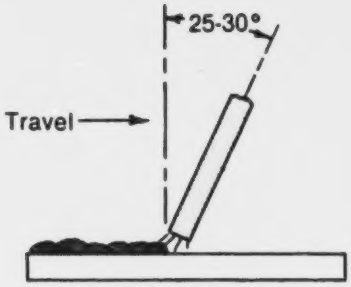
Side View

2. Place metal on work table directly in front of you.
3. Move electrode down close to the base metal being careful not to strike an arc, then lower your welding hood to a safe operating position.
4. Strike an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.
5. Withdraw the electrode just as the arc is struck to form an arc, and then lower the electrode to minimal arc length.

6. Make the bead while holding the electrode perpendicular to the plate at an angle 25 to 30 degrees in the direction of travel while using a drag technique.



End View



Side View

7. Crater and backfill at the edge of the plate.

8. Take electrode from holder and place holder on hook.

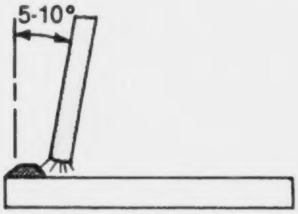
9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.

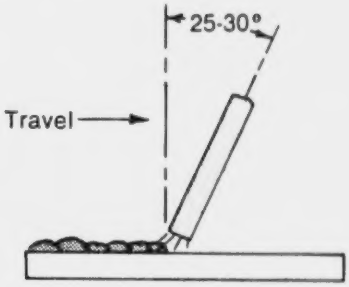
10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.

11. Have your instructor check your work.

12. Reinsert electrode in holder and position yourself properly over the workpiece.

13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead and the electrode is 5 to 10 degrees short of perpendicular.





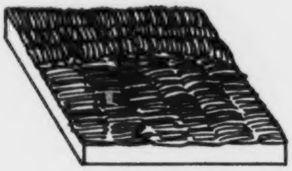
14. Continue using the drag technique to complete second bead so that it is the same legth as the first bead, then stop, clean, and inspect.

15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keep the electrode adjusted 5 to 10 degrees short of perpendicular.

16. Clean each bead thoroughly and inspect for defects.

17. Complete first layer of beads and inspect the pad.

18. Turn the workpiece at a 90 degree angle and weld the first bead on the second layer using the same drag technique as used on the first layer.

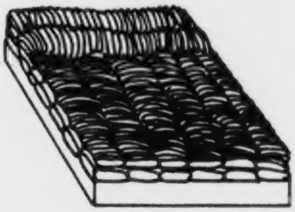


19. Clean and inspect first bead on the second layer, then continue with all beads on the second layer, being sure to adjust electrode angle and continue using the drag technique with each bead.

20. Clean and inspect each bead.

21. Have your instructor check your completed second layer.

22. Turn the workpiece at a 90 degree angle and weld the first bead of the third layer the same as the first beads on layers one and two.



23. Clean and inspect the first bead of the third layer, then continue making beads to complete the third layer on the pad.

24. Adjust electrode angle as required and continue to use the drag technique.

25. Complete, clean, and inspect third layer and have your instructor check your work.

26. Continue adding layers to the pad as directed by your instructor.

27. Stop after each layer and have your instructor check your work.

28. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet as directed by your instructor.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with E6010

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to weld to specifications a fillet weld lap joint in the flat position with E6010 correctly.

TOOLS AND EQUIPMENT:

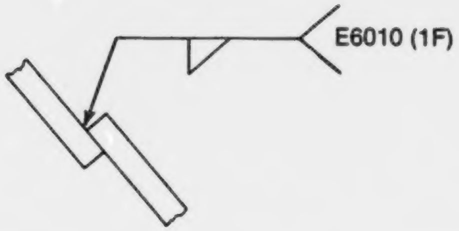
SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Safety glasses
Ground clamp

GENERAL INSTRUCTIONS: Follow procedures to weld to the specifications a fillet weld lap joint in the flat position with E6010 properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Specifications

1. Joint design and weld symbol:

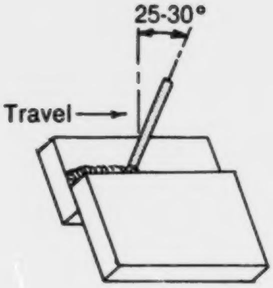


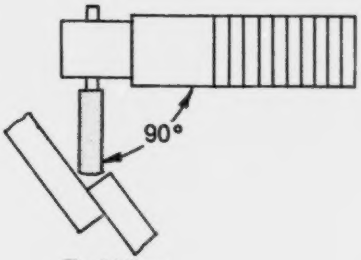
2. Filler metal and number of beads: E6010, 1/8-in. or 5/32-in., single pass
3. Electrical characteristics: DC +
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Break test
8. Technique: Whipping
9. References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure

1. Attach ground clamp to table or workpiece.
2. Select correct polarity for electrode.
3. Turn on welding machine.
4. Adjust to correct amperage by running short beads on scrap material.
5. Prepare plates as required to form the joint and tack weld both ends of the joint.
6. Place the joint so the weld will be in the correct position.

7. Place electrode in holder as indicated.





End View

8. Strike arc and adjust electrode to correct arc length.

9. Adjust travel speed and electrode angle as required to make correct bead shape.

10. Weld the entire length of the joint, and crater and backfill at the edge of the joint.

11. Secure the workpiece with pliers and chip and brush the weld.

12. Inspect weld visually for undercutting, too much spatter, and bead shape.

13. Have your instructor check your work.

14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

16. Tack weld plates back together or turn over as directed by your instructor.

17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

18. Secure workpiece with pliers and chip and brush.

19. Inspect and test weld.

20. Have your instructor check your work.

21. Turn off machine.

22. Check in tools and materials and clean area or prepare for next job sheet as directed by instructor.

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JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with E7018

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to weld to specifications a fillet weld lap joint in the flat position with E7018 correctly.

TOOLS AND EQUIPMENT:

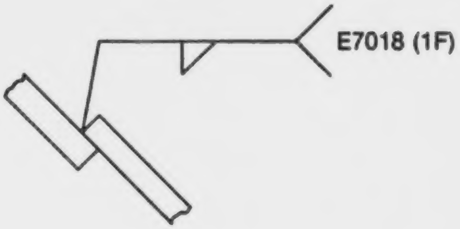
SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Ground clamp

GENERAL INSTRUCTIONS: Follow procedures to weld to specifications a fillet weld lap joint in the flat position with E7018 properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Specifications

1. Joint design and weld symbol:

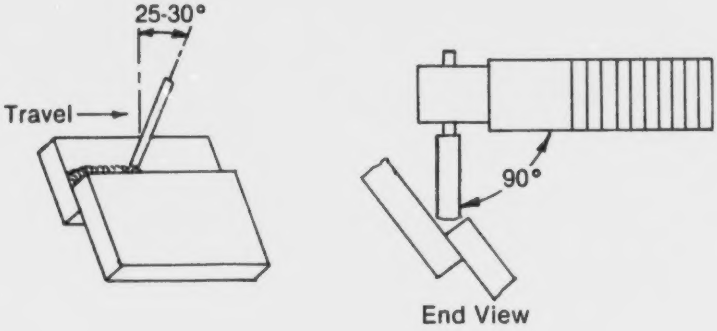


2. Filler metal and number of beads: E 7018, 1/8-in. or 5/32-in., single pass
3. Electrical characteristics: AC or DC reverse
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Break test
8. Technique: Drag
9. References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure

1. Attach ground clamp to table or workpiece.
2. Select correct polarity for electrode.
3. Turn on welding machine.
4. Adjust to correct amperage by running short beads on scrap material.
5. Prepare plates as required to form the joint and tack weld both ends of the joint.
6. Place the joint so the weld will be in the correct position.

7. Place electrode in holder as indicated.



8. Strike arc and adjust electrode to correct arc length.
9. Adjust travel speed and electrode angle as required to make correct bead shape.
10. Weld the entire length of the joint, and crater and backfill at the edge of the joint.
11. Secure the workpiece with pliers and chip and brush the weld.
12. Inspect weld visually for undercutting, too much spatter, and uniform bead shape.
13. Have your instructor check your work.
14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.
15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.
16. Tack weld plates back together.
17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
18. Secure workpiece with pliers and chip and brush.
19. Inspect and test weld.
20. Have your instructor check your work.
21. Turn off machine.
22. Check in tools and materials and clean area or prepare for next job sheet as directed by instructor.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Introduction to Shielded Metal Arc Welding

TOPIC: Weld to Specifications a Fillet Weld Multi-Pass Tee Joint in the Flat Position with E7018

ESSENTIAL ELEMENT(S): (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE(S): After completing this lesson, the student(s) will be able to weld to specifications a fillet weld multi-pass tee joint in the flat position with E7018 correctly.

TOOLS AND EQUIPMENT:

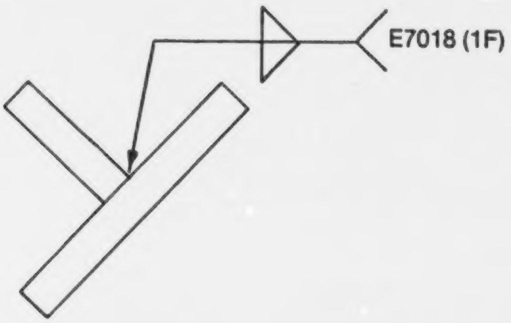
SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Fitter's hammer
Bench vise
Mild steel plates as selected by instructor
Safety glasses
Ground clamp

GENERAL INSTRUCTIONS: Follow procedures to weld to specifications a fillet weld multi-pass tee joint in the flat position with E7018 properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

Specifications

1. Joint design and weld symbol:

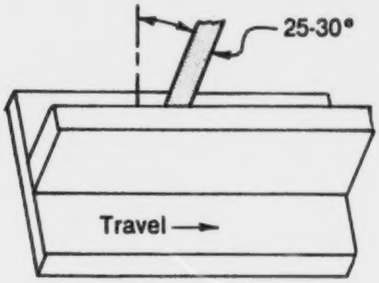


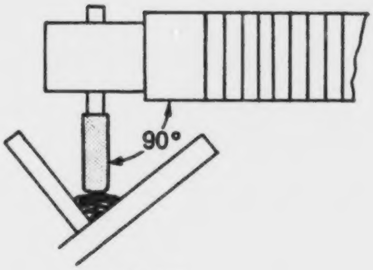
2. Filler metal and number of beads: E 7018, 1/8-in. or 5/32-in., three or more passes
3. Electrical characteristics: DC+ or AC reverse
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag
9. References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure

1. Attach gound clamp to workpiece.
2. Select correct polarity for electrode.
3. Turn on welding machine.
4. Adjust to correct amperage by running short beads on scrap material.
5. Prepare plates as required to form the joint and tack weld both ends of the joint.
6. Place the joint so the weld will be in the correct position.

7. Place electrode in holder as indicated.





End View

8. Strike arc and adjust electrode to correct arc length.

9. Adjust travel speed and electrode angle as required to make correct bead shape.

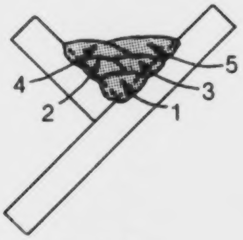
10. Weld the entire length of the joint, and crater and backfill at the edge of the plate.

11. Secure the workpiece with pliers and chip and brush the weld.

12. Inspect weld visually for undercutting, too much spatter, and bead shape.

13. Have your instructor check your work.

14. Weld other passes as required and be sure to clean and inspect each pass.



End View

15. Have your instructor check your work.

16. Turn off machine.

17. Check in tools and materials and clean area or prepare for next job sheet as directed by instructor.

JOB SHEET

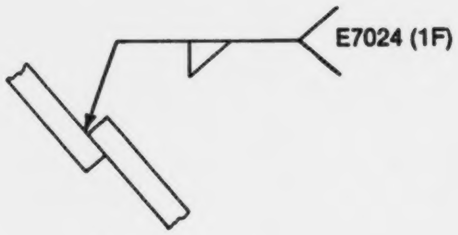
WELDING

NAME ______________________________ **DATE** ____________________

UNIT:	Introduction to Shielded Metal Arc Welding
TOPIC:	Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with E7024
ESSENTIAL ELEMENT(S):	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(D), (ddd)(3)(E)
SPECIFIC OBJECTIVE(S):	After completing this lesson, the student(s) will be able to weld to specifications a fillet weld lap joint in the flat position with E7024 correctly.
TOOLS AND EQUIPMENT:	SMAW machine with accessories Personal safety clothing and equipment Pliers Chipping hammer and wire brush Fitter's hammer Bench vise Mild steel plates as selected by instructor Safety glasses Ground clamp
GENERAL INSTRUCTIONS:	Follow procedures to weld to specifications a fillet weld lap joint in the flat position with E7024 properly.
PROCEDURES AND/OR TASKS:	**Note:** *Follow safety precautions.*

Specifications

1. Joint design and weld symbol:

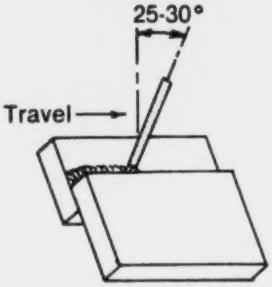


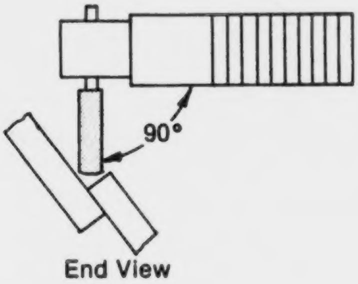
2. Filler metal and number of beads: E 7024, 1/8-in. or 5/32-in., single pass
3. Electrical characteristics: AC, DC+, or straight
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Break test
8. Technique: Drag
9. References: AWS A2.4-79 (4.1) and AWS B3.0-77 (4.2)

Procedure

1. Attach ground clamp to table or workpiece.
2. Select correct polarity for electrode.
3. Turn on welding machine.
4. Adjust to correct amperage by running short beads on scrap material.
5. Prepare plates as required to form the joint and tack weld both ends of the joint.
6. Place the joint so the weld will be in the correct position.

7. Place electrode in holder as indicated.





8. Strike arc and drag electrode to correct electrode angle.

9. Adjust travel speed and electrode angle as required to make correct bead shape.

10. Weld the entire length of the joint, and crater and backfill at the end of the plate.

11. Secure the workpiece with pliers and chip and brush the weld.

12. Inspect weld visually for undercutting, too much spatter, and uniform bead shape.

13. Have your instructor check your work.

14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

15. Inspect bead to see if it breaks in the middle as it should and to make sure it has even penetration on both plates.

16. Tack weld plates back together.

17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

18. Secure workpiece with pliers and chip and brush.

19. Inspect and test weld.

20. Have your instructor check your work.

21. Turn off machine.

22. Check in tools and materials and clean area or prepare for next job sheet as directed by instructor.

STUDENT INFORMATION SHEET

WELDING

UNIT:	Welding Joints and Positions
TOPIC:	Welding Joints and Positions
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(A), (ddd)(3)(E)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to use the correct welding terminology in pointing out the factors involved in producing a quality arc weld.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to prepare and lay a V-butt arc weld, run a continuous bead without breaking an arc, and weld in the various welding positions correctly.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with welding joints and positions include oral and written communications, application of mathematical principals, reading concepts, and science.*

Terms and Definitions

Face of weld is the exposed surface of a fusion weld.

Fusion is the joining of two pieces of metal by heating the adjoining edges to the melting point, allowing them to flow together, and then cool.

Horizontal position weld is a weld laid on a horizontal seam on a piece of metal.

Pads are the metal plates that have beads running side by side and slightly overlapping where the beads form a solid mass.

Penetration is the depth to which the heat of the arc melts the metal during welding.

Pinhole is the small hole in the weld metal caused by trapped gases.

Porousness results when gas pockets have formed in the metal of weld area.

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Puddle is the area on a weld where the metal is molten from the heat of the arc.

Rate of travel is the speed the electrode is moved across the weld area.

Root of weld is the bottom or the part of a weld farthest from the application of weld heat.

Slag deposits are the non-metallic porous material in weld metal.

Stringer bead is the first of several welds to be laid on a weld joint.

Tack weld is a short weld made to hold parts in place until the final weld can be made.

Undercut is the part of the weld crater left unfilled because of incorrect electrode movement or too much amperage.

Vertical position weld is a weld laid on a vertical seam on a piece of metal.

Weave is the movement of the electrode during welding to provide the proper width and buildup.

Whipping is a term applied to a rapid movement of the electrode to prevent overheating the weld area and allowing the molten metal to solidify.

Preparing to Weld

Factors to consider when setting welder amperage

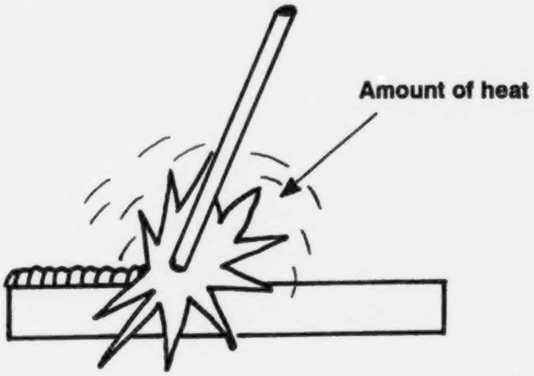
- Length and size of welding cables
- Thickness of base metal
- Welding technique
- Diameter of electrode
- Type of welder
- Polarity on a DC welder
- Type of welding joint or position

Factors to consider when selecting electrodes

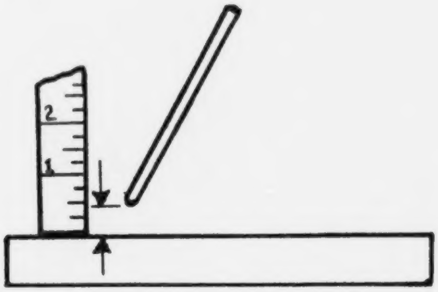
- Welding position
- Strength of weld desired
- Type of base metal
- Welding current (AC or DC)
- Thickness of base metal at weld area
- Design of the weld joint

Factors that affect the quality of a weld

A. Amperage



B. Arc length



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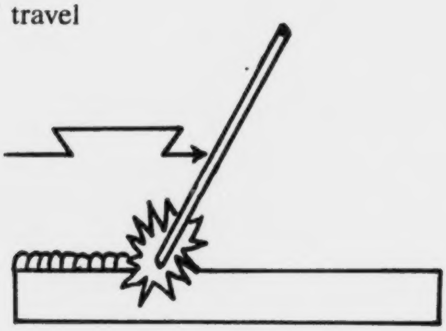
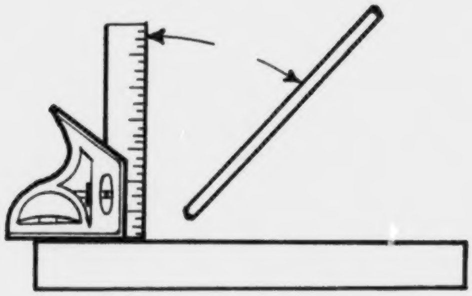
C. Rate of travel



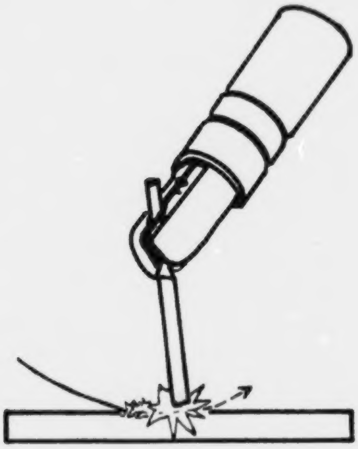
D. Angle of electrode



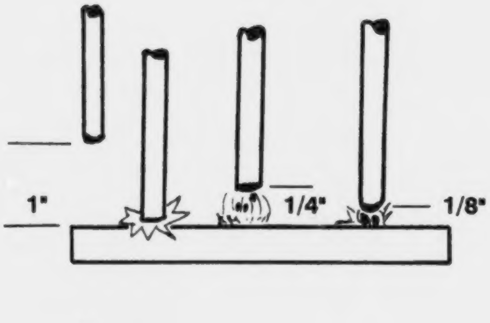
Making the Weld

Methods of striking an arc

A. Scratching



B. Tapping



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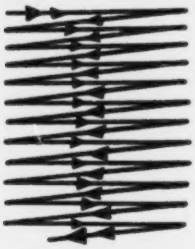
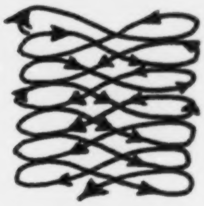
Weave patterns

A.



C.



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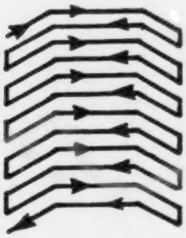
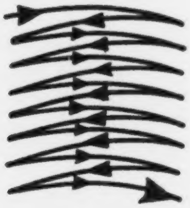


D.



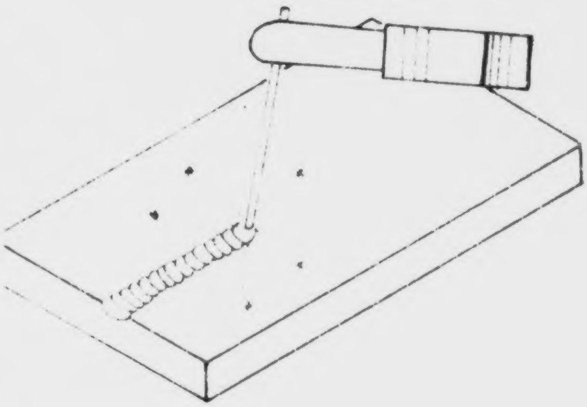
Reasons for fusing one bead to another in a weld

- Makes weld stronger
- Improves penetration
- Improves the appearance

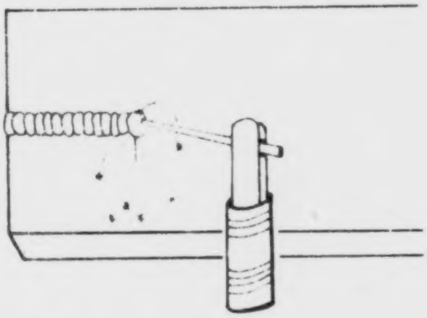
Reasons to remove slag

- Allows better fusion of other beads
- Prevents slag deposits from forming in a bead
- Improves appearance of a weld

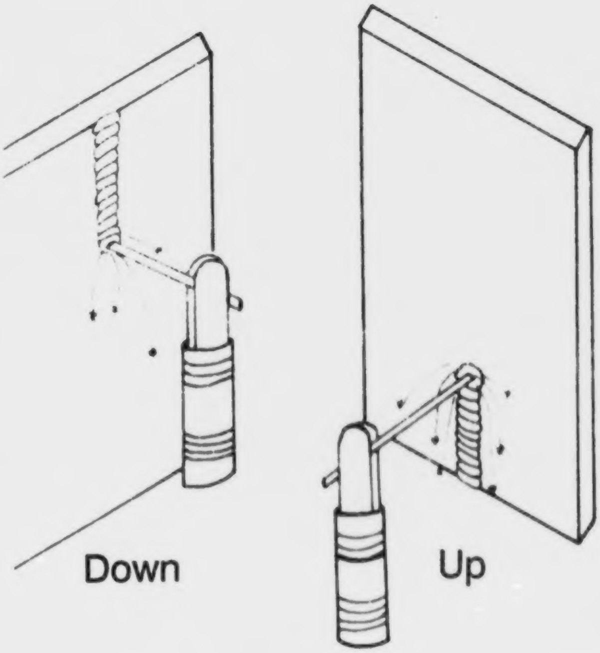
Welding Positions



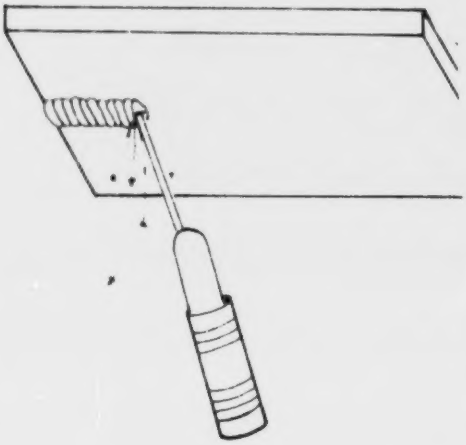
Flat



Horizontal



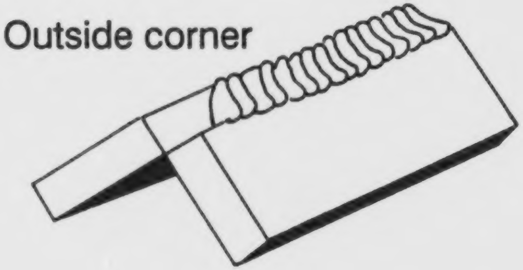
Vertical



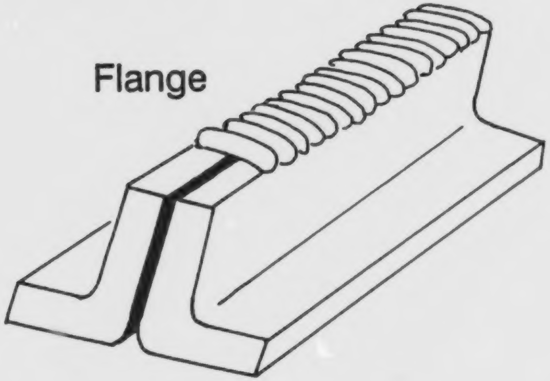
Overhead

TM-1

Welding Joints

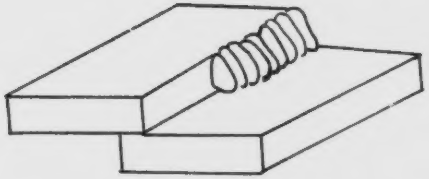


Outside corner

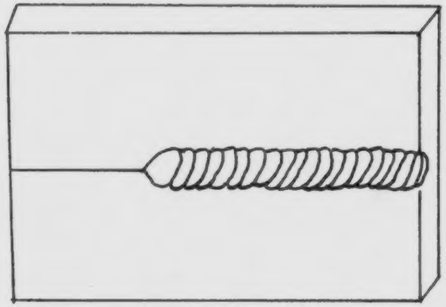


Flange

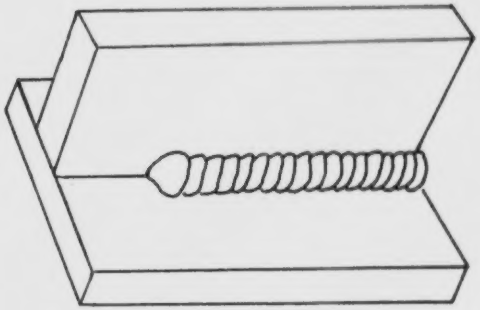
No filler rod required



Lap

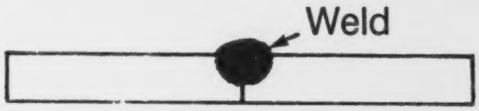


Butt

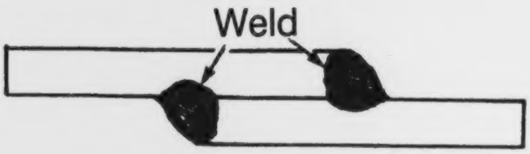


Inside corner or tee weld

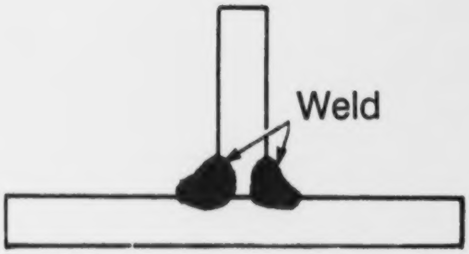
Welding Joints



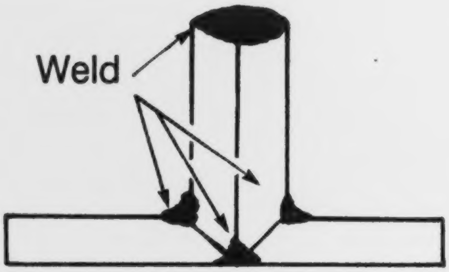
Butt Joint



Lap Joint



Tee Joint



Edge Joint

ASSIGNMENT SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Welding Joints and Position

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the terms associated with arc welding to the correct definition by placing the correct number to the left of the letter.

_____a. Joining two pieces of metal by heating the adjoining edges to the melting point, allowing them to flow together, and then cooling

_____b. The depth the heat of the arc melts the metal during welding

_____c. The exposed surface of a fusion weld

_____d. The bottom or the part of a weld farthest from the application of weld heat

_____e. A weld laid on a horizontal seam on a piece of metal

_____f. A weld laid on a vertical seam on a piece of metal

_____g. Metal plates which have beads running side by side and slightly overlapping so that the beads form a solid mass

_____h. Weld metal that has gas pockets in the weld area

1. Tack weld
2. Horizontal position weld
3. Porousness
4. Vertical position weld
5. Fusion
6. Puddle
7. Rate of travel
8. Weave
9. Penetration

_____i. The part of the weld crater left unfilled because of incorrect electrode movement or too much amperage

_____j. A small hole in the weld metal caused by trapped gases

_____k. A non-metallic porous material trapped in weld metal

_____l. A short weld made to hold parts in place until the final weld can be made

_____m. The area on a weld where the metal is molten from the heat of the arc

_____n. The movement of the electrode during welding to provide the proper width and buildup

_____o. A term applied to a rapid movement of the electrode to prevent overheating the weld area and allow the molten metal to solidify

_____p. The speed the electrode is moved across the weld area

10. Pinhole
11. Pads
12. Face of weld
13. Undercut
14. Root of weld
15. Whipping
16. Slag deposits

2. Point out the factors to consider when setting welder amperage by placing a “ √ ” in front of each of the following phrases that must be considered.

______ a. Length and size of welding cables

______ b. Length of electrode

______ c. Thickness of base metal

______ d. Welding technique

______ e. Diameter of electrode

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______ f. Type of welding gloves

______ g. Type of welder

______ h. Polarity of a DC welder

______ i. Type of welding joint or position

3. Select the factors one must consider when selecting electrodes by answering **YES** or **NO** to each of the following phrases:

______ a. Welding position

______ b. Type of ventilation system in the shop

______ c. Strength of weld desired

______ d. Type of base metal

______ e. Welding current (AC or DC)

______ f. Thickness of base metal at weld area

______ g. Design of weld joint

______ h. Amount of moisture in the air

4. Determine the factors that affect the quality of a weld by underlining the following phrases that affect a weld's quality.

a. Amperage

b. Arc length

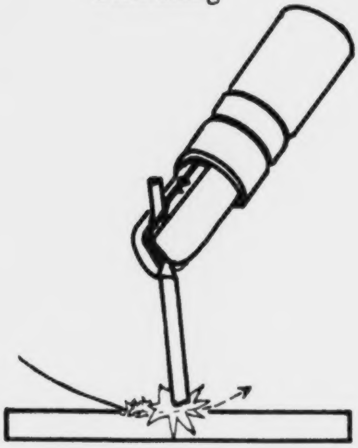
c. Rate of travel

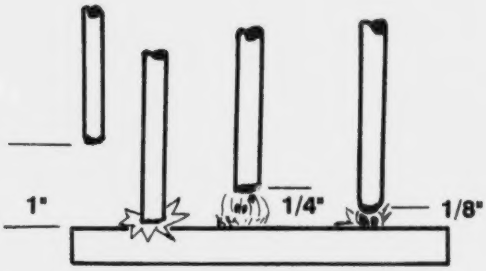
d. Thickness of metal

e. Angle of electrode

5. Select the methods of striking an arc by placing the correct word from the list by the illustration representing each.

Dragging
Tapping
Scratching
Slapping



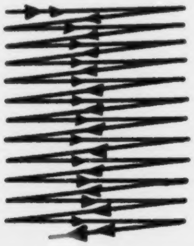


_________________a.

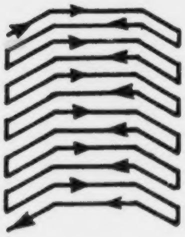
_________________b.

6. Identify the proper weave patterns by placing a "√" in front of each of the usable patterns.

_____ a.



_____ b.



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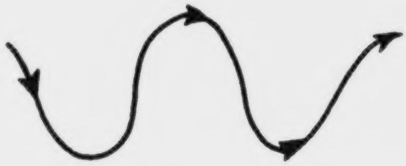
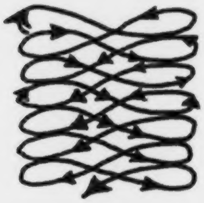
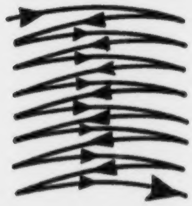
______ c.



______ d.



______ e.



7. List three reasons for fusing one bead to another in a weld.

   a.

   b.

   c.

8. Pick out the correct reasons to remove slag by placing a check in front of each.

   ______ a. Allows better fusion of other beads

   ______ b. Gives welder time to rest between welds

   ______ c. Prevents slag deposits from forming in a bead

   ______ d. Improves appearance of a weld

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Run a Stringer Bead

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to run a stringer bead correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—3/8 x 6 x 6-in.
1/8-in. E6013 electrodes
Coveralls
Soapstone and straightedge

GENERAL INSTRUCTIONS: Follow procedures to run a stringer bead properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety procedures.*

1. Put on coveralls, helmet, and gloves.
2. Prepare plate by making parallel soapstone lines 1-in. apart across the plate.
3. Adjust welding machine to correct amperage setting.
4. Sit or stand in a comfortable position.
5. Strike an arc at the left end of the first line.
6. Run a stringer bead the full length of the plate.

7. Clean the bead and inspect for faults.

8. Run a second bead correcting any faults found in the first bead.

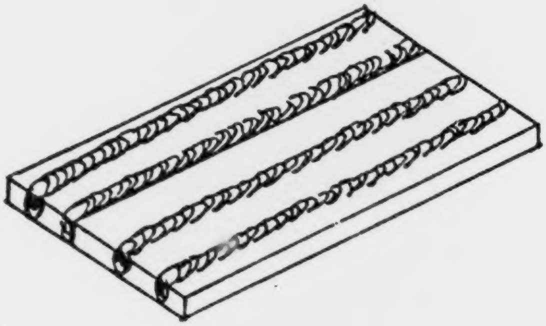
9. Inspect the second bead and compare to the first.

10. Continue running beads on soapstone lines and compare them to the other beads.

11. Prepare a plate to be turned in with at least 4 parallel beads.

12. Turn in finished work to the instructor for grading.

13. Clean area and replace tools and materials to proper place.



JOB SHEET
WELDING

NAME ______________________ **DATE** ______________

UNIT: Welding Joints and Positions

TOPIC: Start, Stop, and Restart the Bead

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to start, stop, and restart the bead correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—3/8 x 6 x 6-in.
1/8-in. E6013 electrodes
Coveralls

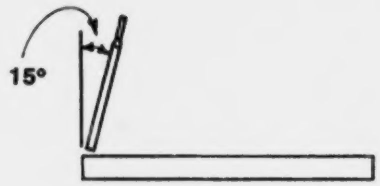
GENERAL INSTRUCTIONS: Follow procedures to start, stop, and restart the bead properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

To start a bead

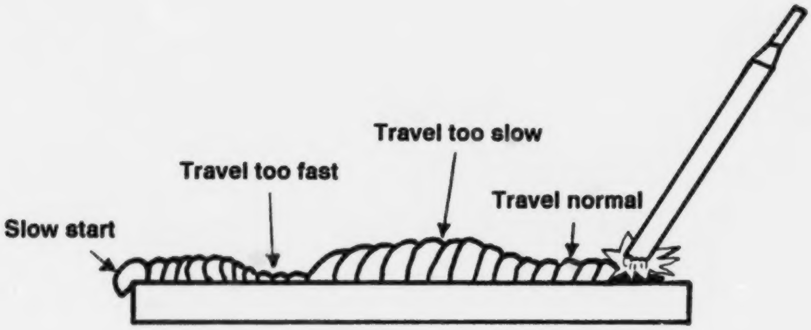
1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to approximate amperage setting.
3. Prepare metal and equipment for welding.
4. Sit or stand in a comfortable position.
5. Hold the electrode perpendicular to the plate where the weld is to be started.

6. Slant electrode 10 to 15 degrees in the direction of travel.



7. Lower the electrode and lightly strike, with a match striking motion, the edge of the plate.
8. Raise the electrode as the arc starts to preheat the metal.
9. When the metal begins melting, lower the electrode to form the correct arc length.
10. Move the electrode in a circular pattern to obtain the desired width of bead.
11. When the desired molten puddle forms, move the electrode slowly down the area to be welded using one of the weave patterns.

Note: *The rate of travel determines the amount of buildup on the weld.*



To stop a bead

1. When the desired length of weld is reached, return the electrode to a perpendicular position.
2. Lower electrode slightly to shorten arc.

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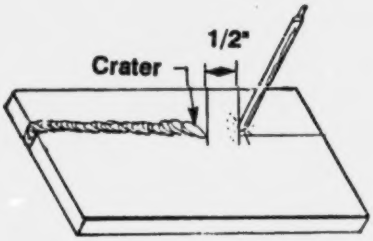
3. Move the electrode back and forth in the crater to form the desired bead width and buildup.
4. Raise the electrode quickly to break the arc.

To restart a bead

1. Chip slag and clean with a wire brush.
2. Strike an arc about ½-in. in front of the weld stopping point.



3. Move the arc quickly to the center of the crater.
4. When the proper buildup is reached, continue the weave pattern, maintaining the proper travel and bead width.
5. When the desired weld length is reached, stop the bead.
6. Turn in work to instructor.
7. Clean work area and replace tools and materials to proper place.

IV-5-JS-3

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Pad in the Flat Position

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a pad in the flat position correctly.

TOOLS AND EQUIPMENT:

- An arc welder and accessories
- Welder's gloves
- Helmet
- Safety glasses
- Chipping hammer
- Wire brush
- Pliers or vise grips
- Mild steel plate—3/8 x 6 x 6-in.
- 1/8-in. E6013 electrodes
- Coveralls
- Cooling vat

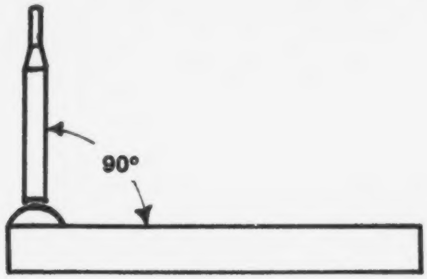
GENERAL INSTRUCTIONS: Follow procedures to be able to make a pad in the flat position properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to approximate amperage setting.
3. Prepare metal and equipment for welding.
4. Sit or stand in a comfortable position.
5. Strike an arc at the end of the plate near either edge.

6. Run a bead parallel to the edge for the entire length of the plate.

   Note: *Be careful not to burn off the edge of the plate.*



End view

7. After completing the first weld, cool the metal in the cooling vat and inspect it for faults.

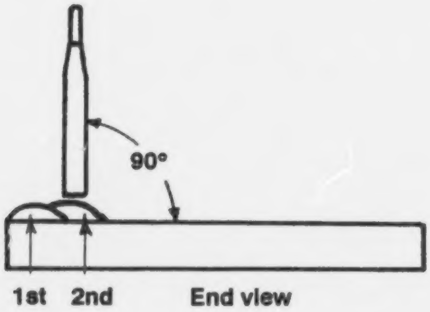
8. Remove **all** slag from the bead.

   Note: *Some faults to check for are pinholes, crater holes, slag deposits, or poor stops and starts.*

9. Make necessary adjustments to the amperage if the first weld bead indicates incorrect heat.

10. Run a bead in the opposite direction of the first bead and overlap it about 1⁄3 of its width.

    Note: *The beads should be fused or melted together to become one solid piece without valleys between them.*



End view

11. Continue running beads across the metal, changing directions with each new bead.

12. Clean and inspect each bead to make necessary welding machine adjustments and welding technique improvements.

    Note: *Beads should improve in appearance as the pad is welded.*

13. When the pad is filled with beads, clean the beads and turn the pad in to the instructor for grading.

14. Clean tools and materials and return to proper place.

JOB SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Pad in the Horizontal Position

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a pad in a horizontal position correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—⅜ x 6 x 6-in.
⅛-in. E6011 electrodes
Coveralls
Cooling vat

GENERAL INSTRUCTIONS: Follow procedures to make a pad in a horizontal position properly.

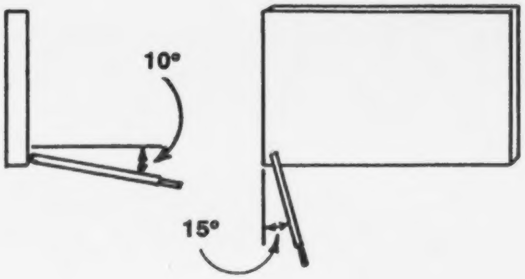
PROCEDURES AND/OR TASKS: **Note:** *Follow safety procedures.*

1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to approximate amperage setting.
3. Prepare metal and equipment for welding.

   Note: *Metal may need to be tack welded to the table in a vertical position.*

4. Sit or stand in a comfortable position.

5. Hold the electrode 10 to 15 degrees in the direction of travel and angled 5 to 10 degrees below the bottom edge of the plate where the bead will be laid.

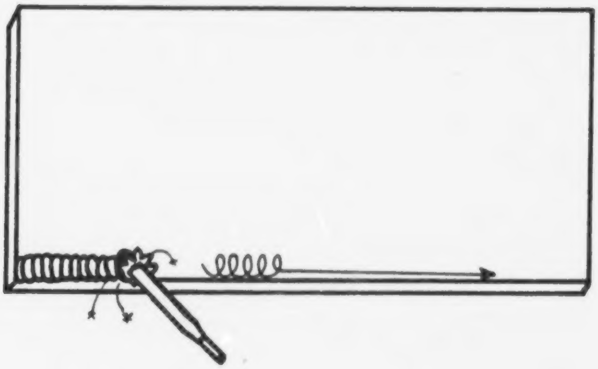


6. Strike an arc and use a whipping technique to keep the molten metal from sagging or running off.

   Note: *When using the whipping technique with a weave pattern on a horizontal weld, the electrode is held at the top edge of the weld puddle slightly longer than at the bottom edge.*

7. Run a bead across the bottom edge of the plate.

   Note: *Keep the bead up on the plate so it does not run off the edge.*



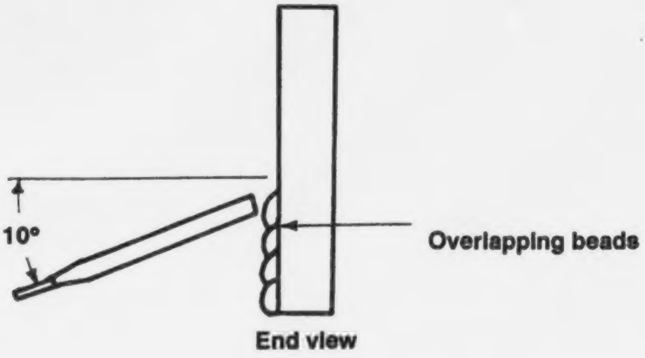
8. When the bead is completed, cool and clean the weld.

9. Inspect the weld for faults.

   Note: *Some faults to check for are pinholes, crater holes, slag deposits, or poor stops and starts.*

10. Make necessary adjustments in the amperage setting if the weld bead indicates incorrect heat.

11. Continue running beads across the plate changing directions each pass and overlapping each previous bead 1/3 of its width.



12. Clean and inspect each bead and make necessary machine adjustments or welding technique improvements.

    Note: *Beads should improve in appearance as pad is welded.*

13. When the pad is filled with beads, remove all slag and turn the pad in to the instructor for grading.

14. Clean tools and materials and put in proper place.

JOB SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Pad in the Vertical-Up Position

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(F)

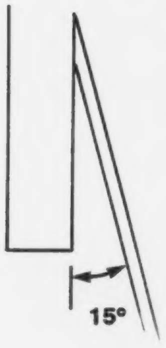
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a pad in the vertical-up position correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—3/8 x 6 x 6-in.
1/8-in. E6011 electrodes
Coveralls
Cooling vat

GENERAL INSTRUCTIONS: Follow procedures to make a pad in the vertical-up position properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

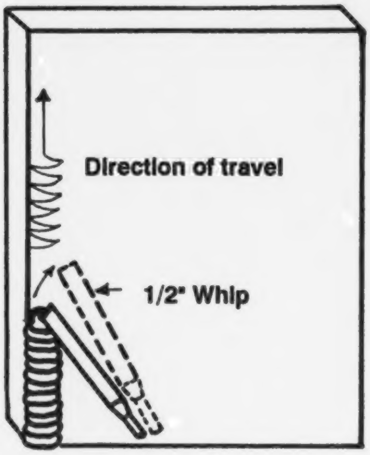


1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to approximate amperage setting.
3. Prepare metal and equipment for welding.

   Note: *Metal should be tack welded to the table in a vertical position.*

4. Sit or stand in a comfortable position.

5. Slant electrode 10 to 15 degrees below the bottom edge of the plate.



6. Strike an arc and begin welding upward on the plate.

7. Whip the end of the electrode in and out of the weld puddle to prevent run-off during the weld pattern.

8. Move the bead to the top edge of the plate, continuing the welding technique the entire length.

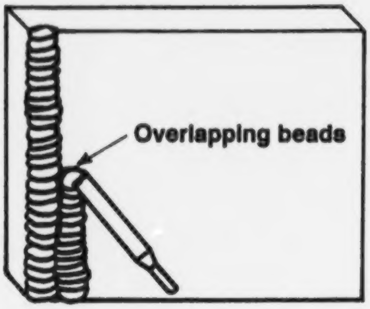
9. After completing the bead, cool and clean the bead.

10. Inspect the bead for faults.

    Note: *Some faults to check for an undercut, pinholes, run-off, slag deposits, and poor starts and stops.*

11. Make necessary adjustments in the amperage setting if the weld bead indicates incorrect heat.

12. Continue running beads, overlapping each previous bead 1/3 of its width.



13. Clean and inspect each bead and make necessary machine adjustments or welding technique improvements.

    Note: *Beads should improve in appearance as pad is welded.*

14. When the pad is filled with beads, clean the beads and turn the pad in to the instructor for grading.

15. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a V-Butt Weld

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a V-butt weld correctly.

TOOLS AND EQUIPMENT:

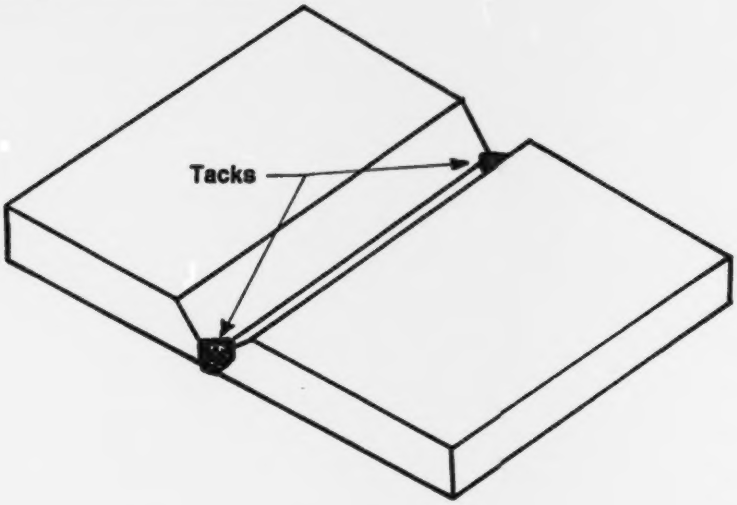
An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—Two 3/8 x 3 x 6-in. beveled plates
5/32-in. E6011 electrodes
Coveralls

GENERAL INSTRUCTIONS: Follow procedures to make a v-butt weld properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

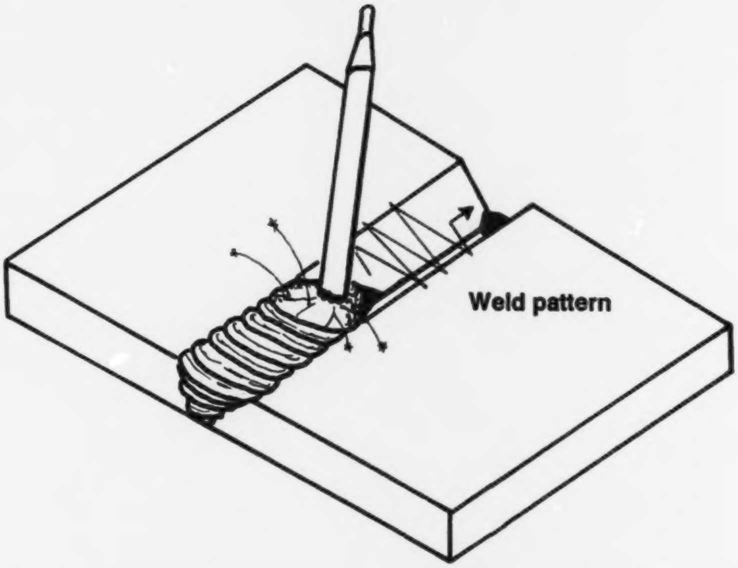
1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to approximate amperage setting.
3. Prepare metal and equipment for welding.
4. Sit or stand in a comfortable position.
5. Space metal plates 1/16-in. apart.
6. Tack weld the plates at both ends.

7. Chip slag from tack welds.



8. Weld pieces, using a single pass weld.

Note: *Use as many rods as necessary to produce the proper buildup in one pass.*



9. Clean weld and inspect for buildup, slag deposits, pinholes, and poor starts and stops.

10. Turn in weld to the instructor for grading.

11. Clean tools and material and put in proper place.

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JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Single Pass Lap Joint

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a single pass lap joint correctly.

TOOLS AND EQUIPMENT:

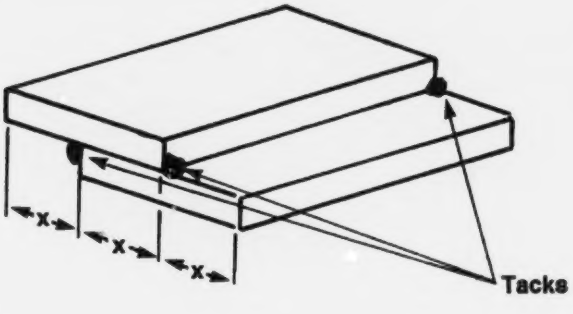
An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—Two 3/8 x 3 x 6-in. plates
5/32-in. E6011 electrodes
Coveralls

GENERAL INSTRUCTIONS: Follow procedures to make a single pass lap joint properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

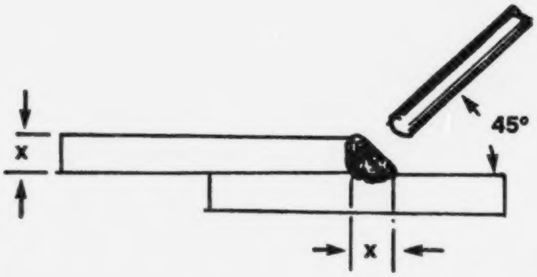
1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal in lap joint positions.

4. Tack weld plates together.



5. Holding the electrode at 45 degree angle, weld the joint.

   Note: *Control the buildup with the rate of travel.*



6. Clean the weld and inspect for buildup, slag deposits, pinholes, and poor starts.
7. Turn in the weld to the instructor for grading.
8. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Single Pass Fillet Weld

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

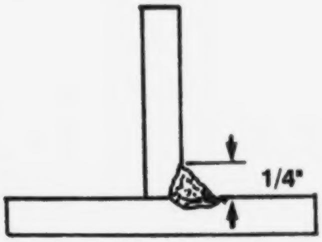
SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a single pass fillet weld correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—Two 3⁄8 x 3 x 6-in. plates
5⁄32-in. E6011 electrodes
Coveralls

GENERAL INSTRUCTIONS: Follow procedures to make a single pass fillet weld properly.

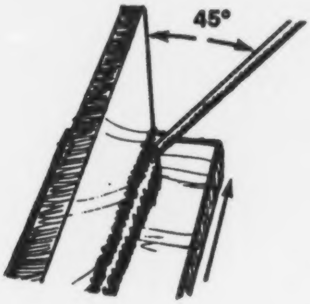
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*



1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal for a tee joint weld.

4. Tack weld pieces of metal together at each end.
5. Weld the joint holding the electrode at 45 degree angle.

   Note: *Lean the electrode slightly in the direction of travel.*



6. Repeat the process until a uniform bead can be made.
7. Turn in the finished weld to the instructor for grading or testing.
8. Clean tools and materials and put in proper place.

JOB SHEET
WELDING

NAME ______________________________ **DATE** __________________

UNIT:	Welding Joints and Positions
TOPIC:	Make a Multiple Pass Fillet Weld
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to make a multiple pass fillet weld correctly.

TOOLS AND EQUIPMENT:

- An arc welder and accessories
- Welder's gloves
- Helmet
- Safety glasses
- Chipping hammer
- Wire brush
- Pliers or vise grips
- Mild steel plate—Two 3/8 x 3 x 6-in. plates
- 5/32-in. E6011 electrodes
- Coveralls

GENERAL INSTRUCTIONS: Follow procedures to make a multiple pass fillet weld properly.

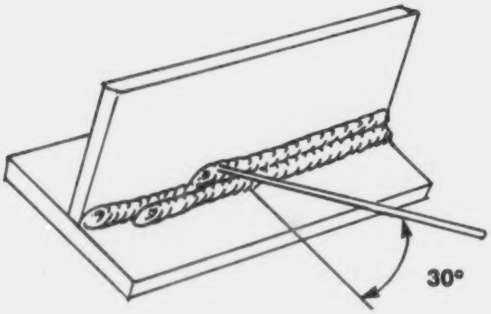
PROCEDURES AND/OR TASKS: **Note:** *Follow safety procedures.*

1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal for a tee joint.
4. Tack weld the pieces of metal together.
5. Holding the electrode at a 45 degree angle, weld the joint.
6. Holding the electrode at a 70 degree angle, make a second pass.

911

7. Clean slag from weld.

8. Holding the electrode at a 30 degree angle, make a third pass.



9. Practice this process until the welds can be made properly.

10. Turn in the finished weld to the instructor for grading and testing.

11. Clean tools and materials and put in proper place.

IV-5-JS-10

JOB SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: Welding Joints and Positions

TOPIC: Make a Lap Joint Using Weave Pattern

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a lap joint using the weave pattern correctly.

TOOLS AND EQUIPMENT:

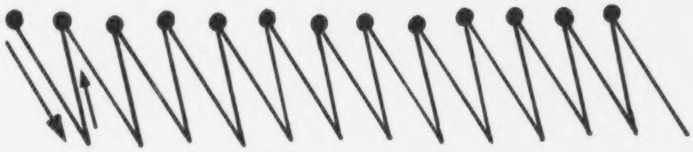
- An arc welder and accessories
- Welder's gloves
- Helmet
- Safety glasses
- Chipping hammer
- Wire brush
- Pliers or vise grips
- Mild steel plate—Two 3/8 x 3 x 6-in. plates
- 5/32-in. E6011 electrodes
- Coveralls

GENERAL INSTRUCTIONS: Follow procedures to make a lap joint using the weave pattern properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal for lap joint.
4. Tack weld the pieces of metal together.
5. Weld the joint, holding the electrode at a 45 degree angle.

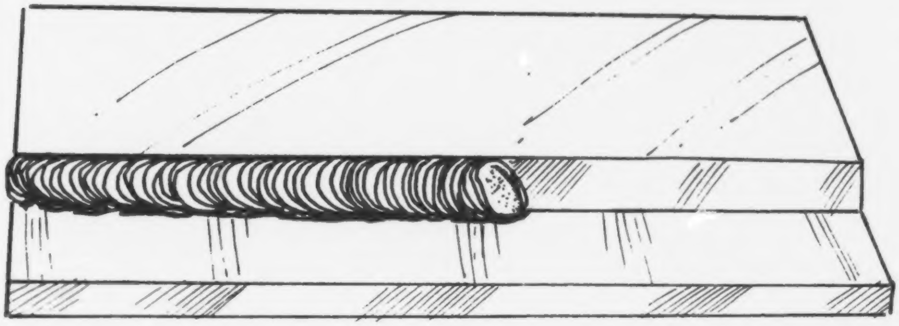
6. Use a weave motion as the weld is made.



7. Make pauses in the weave pattern as shown.

   Note: *This keeps the weld metal from burning away or undercutting.*

8. Repeat the procedure until an even bead can be made.



9. Turn in the finished weld to the instructor for grading and testing.

10. Clean tools and materials and put in proper place.

7

JOB SHEET
WELDING

NAME ______________________________ **DATE** __________________

UNIT: Welding Joints and Positions

TOPIC: Make a Fillet Weld Using Weave Pattern

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to make a fillet weld using the weave pattern correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—Two 3/8 x 3 x 6-in. plates
5/32-in. E6011 electrodes
Coveralls

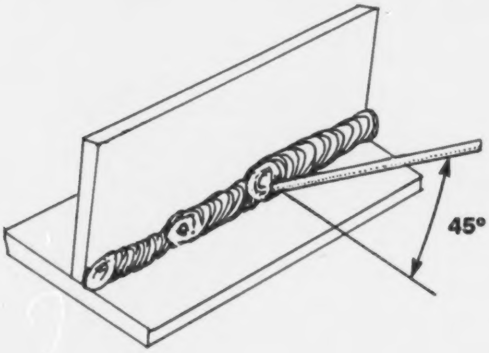
GENERAL INSTRUCTIONS: Follow procedures to make a fillet weld using the weave pattern properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, helmet, and glasses.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal for a tee joint.
4. Tack weld the pieces of metal together.
5. Holding the electrode at a 45 degree angle from the pieces of metal, weld the joint.

6. Use a weave motion as the weld is made.

   Note: *Make several passes, with each overlapping the previous pass.*



7. Make pauses in the weave pattern.

   Note: *This keeps the weld metal from burning away or undercutting.*

8. Repeat the process until an even bead can be made.
9. Turn in the finished weld to the instructor for grading and testing.
10. Clean tools and materials and put in proper place.

JOB SHEET

WELDING

NAME ______________________ **DATE** ______________

UNIT: Welding Joints and Positions

TOPIC: Lay a Vertical-Down Stringer Bead

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(D), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a vertical-down stringer bead correctly.

TOOLS AND EQUIPMENT:

An arc welder and accessories
Welder's gloves
Helmet
Safety glasses
Chipping hammer
Wire brush
Pliers or vise grips
Mild steel plate—3/8 x 6 x 6-in.
1/8-in. E6013 electrode
Coveralls

GENERAL INSTRUCTIONS: Follow procedures to lay a vertical-down stringer bead properly.

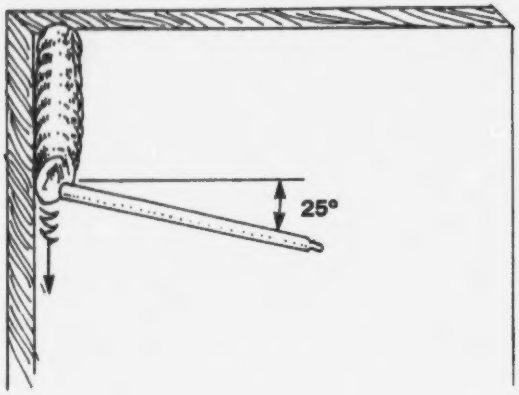
PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Put on coveralls, helmet, and gloves.
2. Adjust welding machine to correct amperage setting.
3. Prepare metal and equipment for welding.

   Note: *Metal should be attached to the welding table in a vertical position.*
4. Sit or stand in a comfortable position.
5. Slant the electrode downward at a 25 to 30 degree angle.

917

6. Strike an arc at the top edge of the metal and begin welding down the plate.



7. Slowly move the weld puddle the length of the plate.

   Note: *Make sure the weld puddle doesn't get below the tip of the electrode and run down the plate.*

8. Clean the weld and check the bead for appearance and penetration.

9. Run a second bead 1-in. from the first, trying to improve the appearance of the weld.

10. Compare it to the first bead.

11. Continue to run vertical-down beads until the weld is made easily.

12. Turn in the finished weld to the instructor for grading and testing.

13. Clean tools and materials and put in proper place.

STUDENT INFORMATION SHEET

WELDING

UNIT:	MIG Welding
TOPIC:	MIG Welding
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(3)(D), (ddd)(3)(E)
UNIT OBJECTIVE:	After completing this unit, the student(s) will be able to make metallic inert-gas (MIG) welded joints.
SPECIFIC OBJECTIVE:	After completing this information sheet, the student(s) will be able to identify terms used with MIG welding, identify and use types of filler wire and MIG weld correctly.
BASIC ACADEMIC SKILLS APPLICATION:	*Basic academic skills used with MIG welding include science, application of mathematical principles, and oral and written communications.*

Introduction to MIG Welding

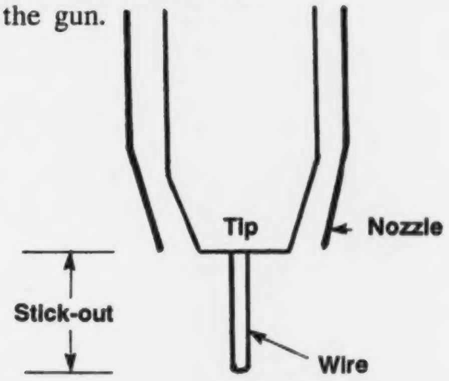
Gas Metal Arc Welding (GMAW) is a welding process using a consumable electrode which is fed to the weld joint and shielded with gas.

Metal Inert-Gas Welding (MIG) is an abbreviation used to describe gas metal arc welding.

Shielding gases replace the air around the arc to prevent oxidation and contamination.

Short arc is a gas metal arc welding process using low voltage, low current, and a small diameter wire.

Stick-out is the distance the wire sticks out past the contact tip of the gun.



Welding current (amperage) is usually direct current reverse polarity, with the electrode (wire) positive and the work negative.

Whiskers are the short welding wires that feed through the weld and extend past the root of the weld.

Advantages of the MIG welding process

- Only a small amount of spatter and no slag are produced.
- Faster welding rates are possible.
- Different metal thicknesses may be welded without changing wire size.
- Gaps and badly fitting joints may be filled easily without burning through.
- Metal distortion is reduced.
- Most alloys may be welded by choosing the correct filler wire and shielding gas.
- Welding can be done in all positions.

Types of MIG welding processes

- The short arc uses low current (amperage), low voltage, and small wire size.

  Note: *This is the most popular of the MIG welding processes.*

- The spray arc employs high current (amperage), high voltage, and large wire size.

  Note: *This process is used on thicker metals.*

- Flux-cored wire is used to weld steel.

  Note: *Some wires of this type do not require shielding gases.*

Factors to consider when selecting filler wire

- Alloy of metal to be welded
- Metal thickness
- Design of weld joint
- Job specifications

Types of welding filler wire

A. Solid

Note: *Solid wire is supplied in the following standard sizes: .035-in., .045-in., 1/16-in., 5/64-in., 3/32-in., and 1/8-in.*

B. Flux-cored

Note: *Flux-cored wire is supplied in the following standard sizes: 1/16-in., 5/64-in., 3/32-in., 7/64-in., 1/8-in., and 5/32-in.*

Shielding gas types

A. Argon

B. Helium

C. CO_2—Carbon dioxide

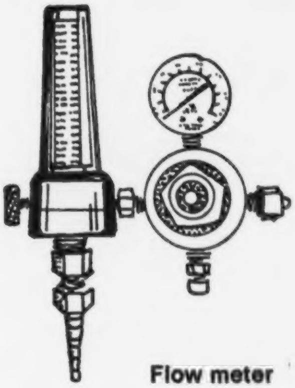
Note: *Shielding gases may be mixed in different amounts, depending on the alloy of the metal being welded.*

Factors to consider when adjusting flow rate of shielding gases

Note: *Shielding gases are supplied in steel cylinders similar to other types of gases.*

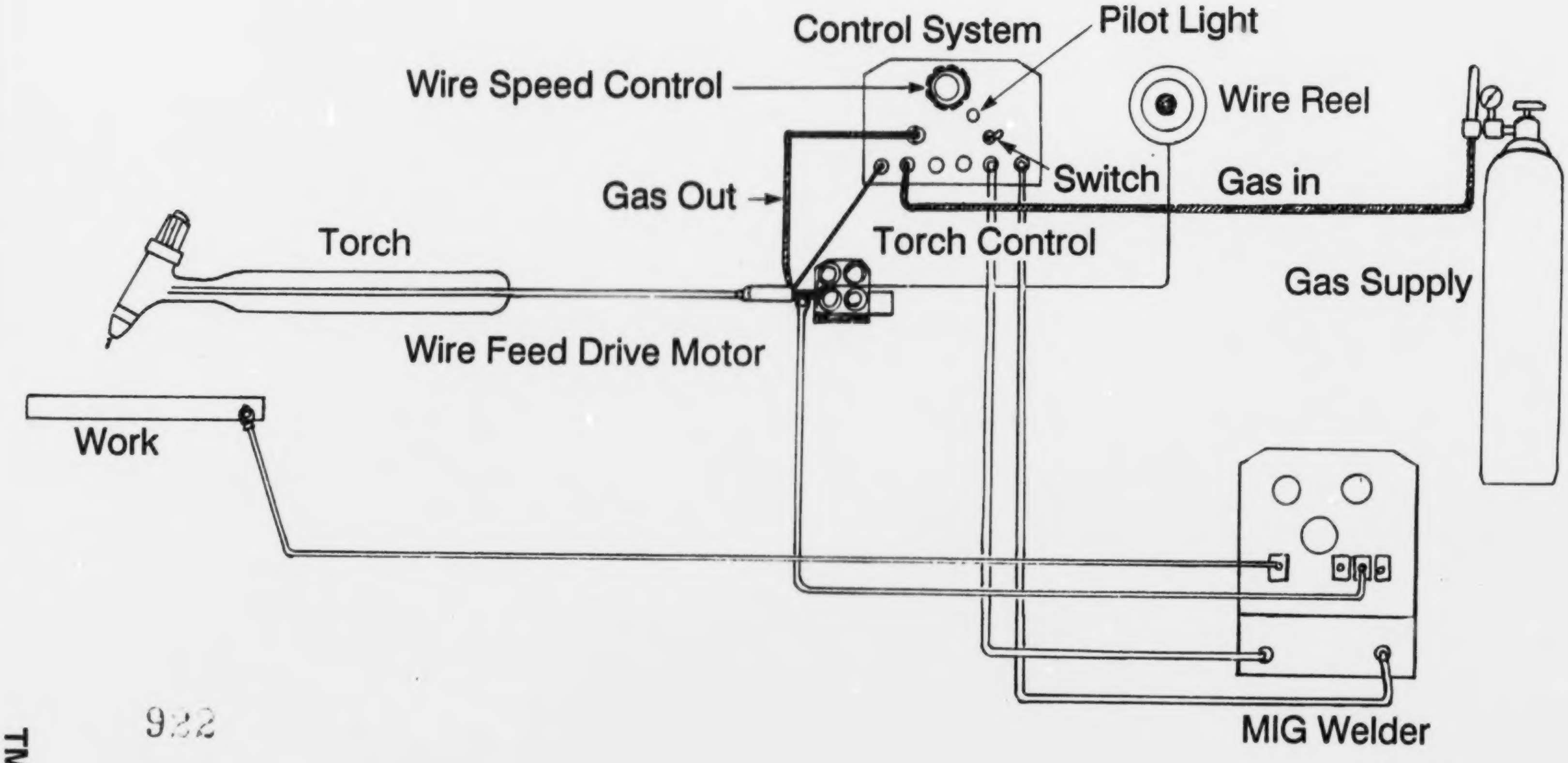
- The amount of shielding gas supplied at the weld is controlled by a gas flow meter.
- The flow rate is measured in cubic feet per hour.
- The flow meter is adjusted to provide the proper amount of shielding gas for the thickness of metal being welded.

Note: *Refer to TM-3 for proper flow rate.*



Flow meter

MIG Welding Outfit

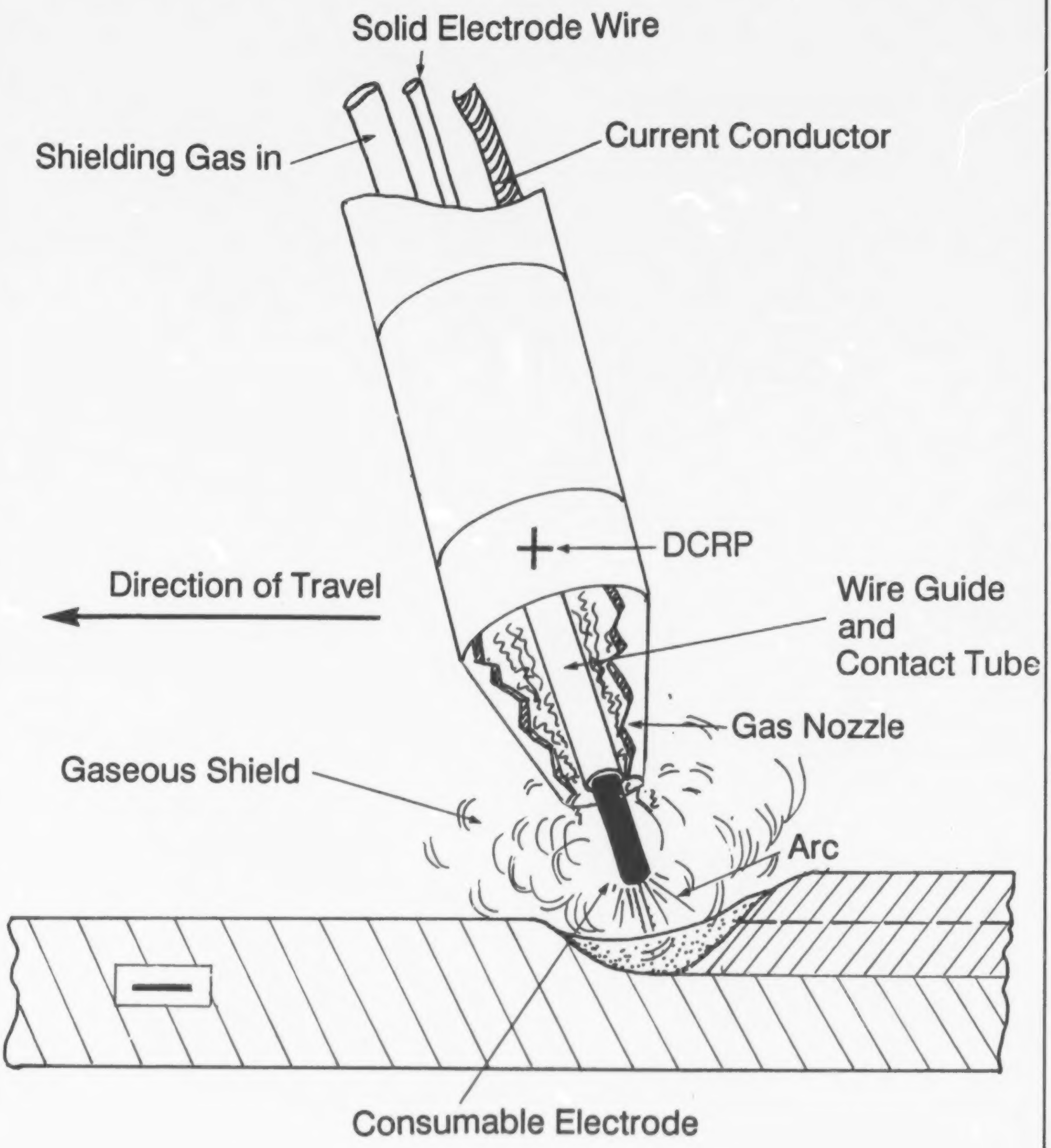

Control System
Pilot Light
Wire Speed Control
Wire Reel
Switch
Gas in
Gas Out
Torch
Torch Control
Gas Supply
Wire Feed Drive Motor
Work
MIG Welder

922

923

TM-1

MIG Welding Process


Solid Electrode Wire
Shielding Gas in
Current Conductor
DCRP
Direction of Travel
Wire Guide and Contact Tube
Gas Nozzle
Gaseous Shield
Arc
Consumable Electrode
+
—

MIG Set-up Chart

All Joints All Positions Mild Steel							
Material Thickness		Number of Passes	Wire Diameter	Welding Conditions DCRP		Gas Flow CFH	Travel Speed IPM
Gage	Inch			Arc Volts	Ampheres		
24	.023	1	.030	15-17	30-50	15-20	15-20
22	.029	1	.030	15-17	40-60	15-20	18-22
20	.035	1	.035	15-17	65-85	15-20	35-40
18	.047	1	.035	17-19	80-100	15-20	35-40
16	.059	1	.035	17-19	90-110	20-25	30-35
14	.074	1	.035	18-20	110-130	20-25	25-30
12	.104	1	.035	19-21	115-135	20-25	20-25
11	.119	1	.035	19-22	120-140	20-25	20-25
10	.134	1	.045	19-23	140-180	20-25	27-32
	3/16 in.	1	.045	19-23	180-200	20-25	18-22
	1/4 in.	1	.045	20-23	180-200	20-25	12-18

ASSIGNMENT SHEET
WELDING

NAME ______________________________ **DATE** ____________________

UNIT: MIG Welding

TOPIC: MIG Welding

DIRECTIONS: Read and answer the following questions in the space provided.

1. Match the following terms and definitions

   1. Shielding gases
   2. Whiskers
   3. Stick-out
   4. Welding current
   5. Short arc
   6. MIG welding
   7. GMAW

_____a. Gases used to displace the air around the arc to prevent oxidation and contamination

_____b. A welding process using a consumable electrode which is fed to the weld joint and shielded with gas

_____c. An abbreviation used to describe gas metal arc welding

_____d. A gas metal arc welding process using low voltage, low current, and small wire diameter

_____e. Usually direct current reverse polarity with the electrode (wire) positive and the work negative

_____f. The distance the wire sticks out past the contact tip of the gun

_____g. Short welding wire that feeds through the weld and extends past the root of the weld

926

2. Point out the advantages of MIG welding by placing a "✓" in the space provided at the left.

   ______ a. Small amount of spatter and no slag

   ______ b. Low welding rate

   ______ c. Different metal thicknesses may be welded without changing wire size

   ______ d. Gaps and badly fitting joints may be filled easily without burning through

   ______ e. Metal distortion is reduced

   ______ f. Welding is possible in one position only

3. Point out the types of MIG welding processes by placing a "✓" in the space provided at the left.

   ______ a. Short arc—uses low current (amperage), low voltage, and small wire size

   ______ b. Spray arc—employs high current (amperage), high voltage, and large wire size

   ______ c. Flux-cored wire—can be used to weld steel without a shielding gas

4. Point out the factors to consider when selecting filler wire by placing a "✓" in the space provided at the left.

   ______ a. Alloy of metal to be welded

   ______ b. Amount of rust on the metal

   ______ c. Metal thickness

   ______ d. Design of weld joint

   ______ e. Job specifications

5. Identify the types of welding filler wire by placing a "✓" in the space provided at the left.

   ______ a. Solid

   ______ b. Flux-cored

   ______ c. Flux coated

6. Identify the types of shielding gases by placing a "√" in the space provided at the left.

   ______ a. Argon

   ______ b. Oxygen

   ______ c. Acetylene

   ______ d. Helium

   ______ e. Carbon dioxide

7. Point out the factors to consider when adjusting shielding gas flow rate by placing a "√" in the space provided at the left.

   ______ a. The amount of shielding gas supplied at the weld is controlled by a gas flow meter.

   ______ b. Too much shielding gas will change the color of the metal being welded.

   ______ c. The flow rate is measured in cubic feet per hour.

   ______ d. The flow meter is adjusted to provide the proper amount of shielding gas for the thickness of metal being welded.

   ______ e. Too little shielding gas will cause the weld to be of high quality.

8. The amount of shielding gas supplied at the weld is controlled by a gas ____________ ____________.

9. The flow rate on a flow meter is measured in ____________ feet per hour.

10. The two types of welding filler wire are ______________ and ___________.

IV-6-JS-1

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

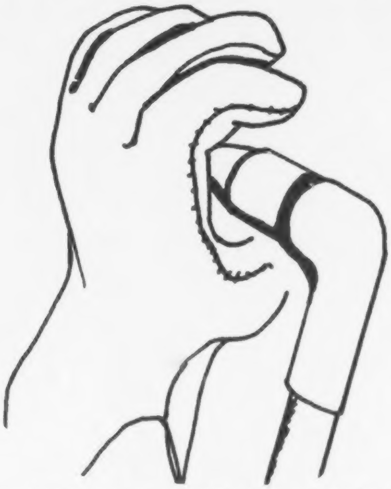
UNIT:	MIG Welding
TOPIC:	Making a MIG Welding Bead
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(3)(D), (ddd)(3)(E)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to make a MIG welding bead correctly.
TOOLS AND EQUIPMENT:	MIG welding equipment 12-gauge weld steel, 6 x 6-in. .035-in. electrode wire CO_2 shielding gas Side cutting pliers Spatter release spray Protective clothing
GENERAL INSTRUCTIONS:	Follow procedures to make a MIG welding bead properly.
PROCEDURES AND/OR TASKS:	**Note:** *Follow safety precautions.*

1. Spray MIG nozzle with spatter release.
2. Turn on and adjust shielding gas flow rate to 20 cubic feet per hour.
3. Lower the welding helmet.

4. Set amperage on scrap metal by squeezing the trigger and starting an arc.

   Note: *Amperage (wire feed speed) should be set at about 110-135 amps.*

   CAUTION: Shield the arc by placing a gloved hand around the nozzle of the gun.



5. Watch the amp meter and volt meter while the arc is being made and make necessary adjustments.

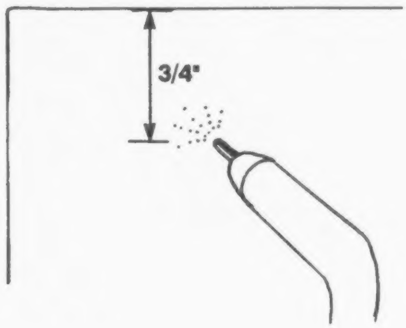
   Note: *Some machines require setting the amperage while the arc is being made.*

6. Place the metal to be welded in the flat position.

7. Use the side cutting pliers to trim the welding wire to stickout about 3⁄8-in.

8. Start the arc about 3⁄4-in. from the top of the plate. Quickly move to the top of the plate and begin the puddle.

   Note: *Starting the weld in this way will produce a better bead without a cold start.*



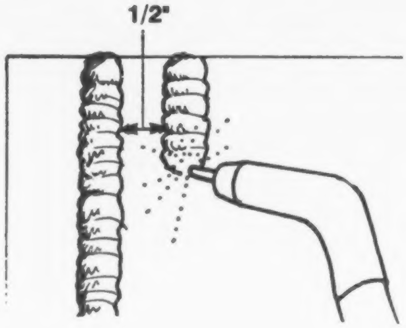
9. Hold the gun straight up and tilt it slightly in the direction of travel.

10. Maintain a wire stick-out of 3⁄8-in.

11. Make a single downhand stringer weld.

    Note: *A crackling or hissing sound of the arc is a good sign of the correct arc length.*

12. Move over about 1⁄2- to 3⁄4-in. and make another bead beside the first bead.



13. Practice making this type of bead until good quality beads are produced easily.

14. Practice starting and stopping and restarting the bead.
    a. Restart the weld about 1⁄2-in. in front of the bead center.
    b. Quickly move the arc back into the crater and establish a puddle.

15. Turn in the finished welds to the instructor for evaluation.

16. Clean area and return tools and materials to proper place.

JOB SHEET
WELDING

NAME ____________________________ **DATE** ____________________

UNIT:	MIG Welding
TOPIC:	Lay a Single-Pass Butt Weld
ESSENTIAL ELEMENTS:	(a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(3)(D), (ddd)(3)(E)
SPECIFIC OBJECTIVE:	After completing this lesson, the student(s) will be able to lay a single-pass butt weld correctly.
TOOLS AND EQUIPMENT:	MIG welding equipment 1/8-in. mild steel (2 pieces) 3 x 6-in. .035-in. electrode wire CO_2 shielding gas Side cutting pliers Spatter release spray Protective clothing
GENERAL INSTRUCTIONS:	Follow procedures to lay a single-pass butt weld properly.
PROCEDURES AND/OR TASKS:	**Note:** *Follow safety precautions.*

1. Spray MIG nozzle with spatter release.
2. Turn on and adjust shielding gas flow rate to 20 cubic feet per hour.
3. Set amperage (wire feed speed) to about 120-140 amps.
4. Place the metal to be welded in the flat position with the 6-in. sides together.

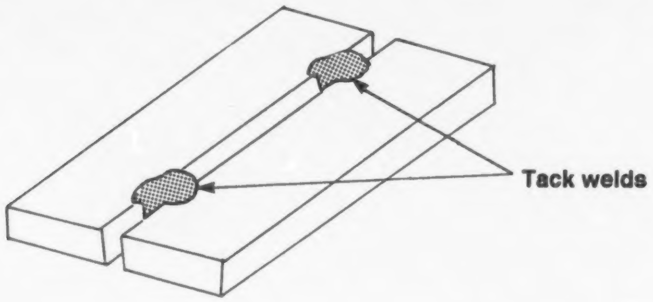
   Note: *Leave a 1/16-in. gap between the two pieces of metal.*

932

5. Tack weld each end of the metal.

6. Begin the weld puddle and maintain a ⅜-in. stick-out.

   Note: *Tilt the MIG gun slightly in the direction of the weld.*



7. At the end of the weld, fill the crater before stopping.

8. Practice making this type of weld until good quality welds are easily produced.

9. Turn in the finished welds to the instructor for evaluation.

10. Clean area and return tools and materials to proper place.

IV-6-JS-3

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: MIG Welding

TOPIC: Lay a Single-Pass Lap Joint

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a single-pass lap joint correctly.

TOOLS AND EQUIPMENT:
MIG welding equipment
1/8-in. mild steel (2 pieces) 3 x 6-in.
.035-in. electrode wire
CO_2 shielding gas
Side cutting pliers
Spatter release spray
Protective clothing
Cooling vat

GENERAL INSTRUCTIONS: Follow procedures to lay a single-pass lap joint properly.

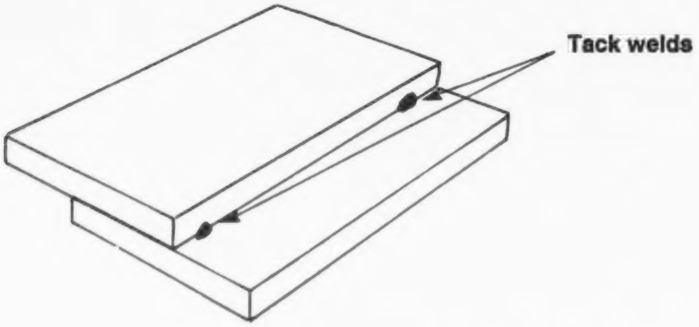
PROCEDURES AND/OR TASKS: **Note**: *Follow safety precautions.*

1. Spray MIG nozzle with spatter release.
2. Turn on and adjust shielding gas flow rate to 20 cubic feet per hour.
3. Set amperage (wire feed speed) to about 120-140 amps.
4. Place the metal to be welded in the lap joint position.

5. Tack weld the metal in position on each end.

6. Turn the metal over and weld the joint on side opposite to the tacks.

   Note: *This procedure will prevent distortion.*



7. Cool weld and examine for defects.

8. Turn metal over and make another weld on the other side.

9. Turn in the finished weld to the instructor for evaluation.

10. Clean area and return tools and materials to proper place.

JOB SHEET

WELDING

NAME ______________________________ **DATE** ____________________

UNIT: MIG Welding

TOPIC: Lay a Tee Weld Joint

ESSENTIAL ELEMENTS: (a)(4), (a)(7)(A), (a)(7)(B), (a)(7)(C), (a)(7)(D), (a)(7)(E), (ddd)(3)(D), (ddd)(3)(E)

SPECIFIC OBJECTIVE: After completing this lesson, the student(s) will be able to lay a tee weld joint correctly.

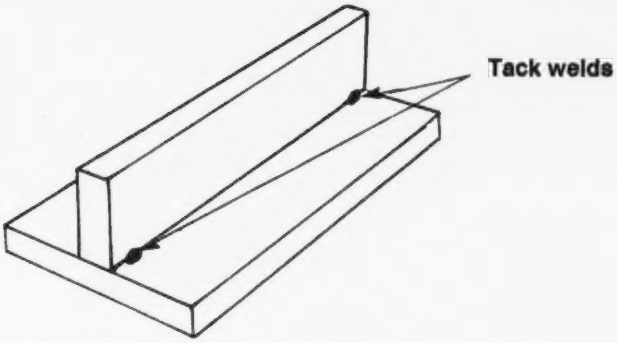
TOOLS AND EQUIPMENT:
MIG welding equipment
⅛-in. mild steel (2 pieces) 3 x 6-in.
.035-in. electrode wire
CO_2 shielding gas
Side cutting pliers
Spatter release spray
Protective clothing
Cooling vat

GENERAL INSTRUCTIONS: Follow procedures to lay a tee weld joint properly.

PROCEDURES AND/OR TASKS: **Note:** *Follow safety precautions.*

1. Spray MIG nozzle with spatter release.
2. Turn on and adjust shielding gas flow rate to 20 cubic feet per hour.
3. Set amperage (wire feed speed) to about 120-140 amps.
4. Maintain a stick-out of ⅜-in.

5. Place the metal to be welded in the tee position with the 6-in. sides together.
6. Tack weld at each end of the metal.
7. Hold the MIG gun at 45 degree angle and lean slightly in the direction of the weld.



8. Weld on the side opposite from the tack welds.
9. Cool the weld and inspect for defects.
10. Turn the plate around and make another weld on the other side.
11. Turn in the finished welds to the instructor for evaluation.
12. Clean area and return tools and materials to proper place.

APPENDIX A

Formulas For Small Engines

Formula for work:

Work = Force x Distance To measure foot pounds

Example: Using 80 lbs of force to move a 3000 pound box 50 feet how much would be accomplished

W = F x D

W = 80 x 50

W = 4000 foot pounds

Horsepower

Horsepower = Force x Distance/Time (sec) x 550 or Weight x Distance/Time (sec.) x 550

One horsepower is 550 foot pounds of work done in one second

Example if a 180 pound person climb a 10 foot flight of stairs in 5 seconds. How much horsepower is developed

HP = W x D/Time (sec) x 550

HP = 180 x 10/5 x 50

HP = 1180/2750

HP = .65 horsepower

Torque

Torque = Force x Radius

Example: Applying 25 pounds of force to a 2 feet long wrench what is the torque

T = F x R

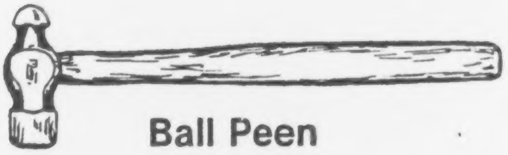
T = 25 x 2

T = 50 pound feet

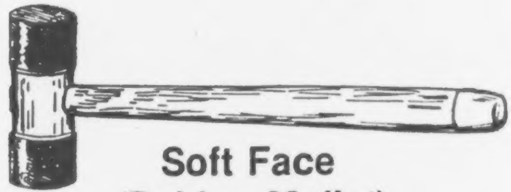
APPENDIX B

Basic Hand Tools

Hammers

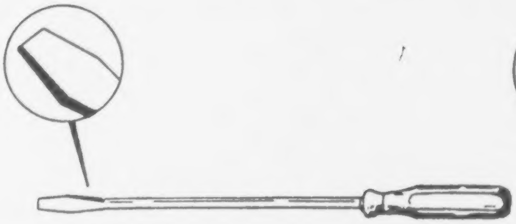


Ball Peen

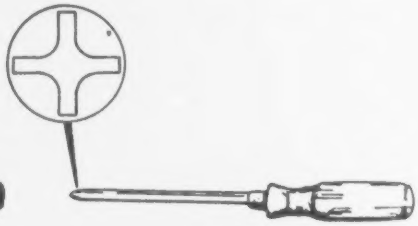


Soft Face
(Rubber Mallet)

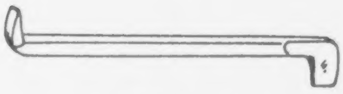
Screwdrivers



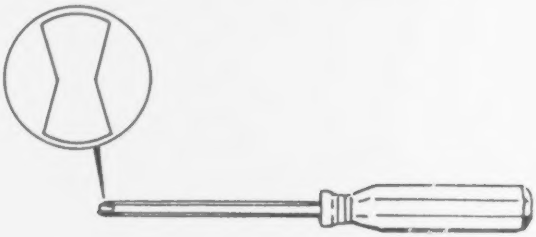
Standard Slot Type



Phillips

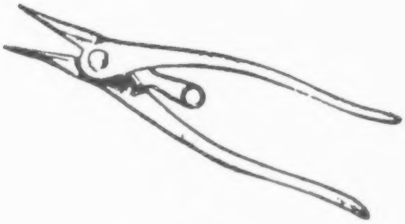


Offset

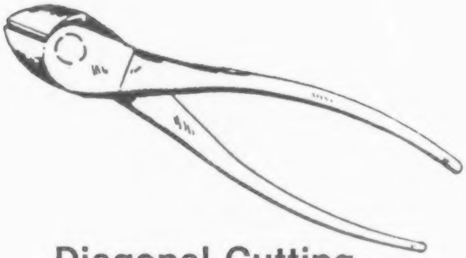


Clutch Head

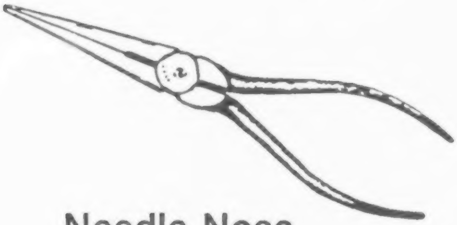
Basic Hand Tools
(Continued)
Pliers



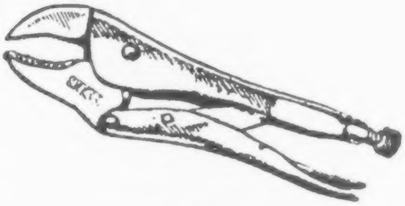
Lock Ring



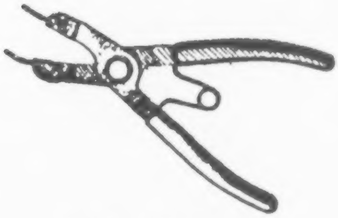
Diagonal Cutting



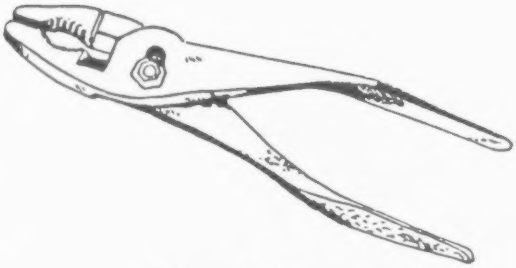
Needle Nose



Vise Grip



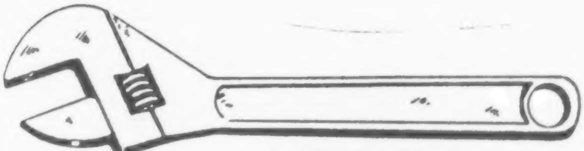
Snap Ring

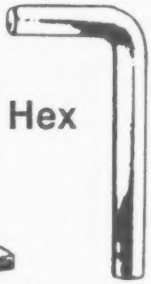


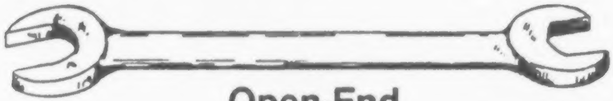
Slip Joint

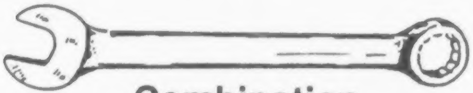
Basic Hand Tools (Continued)

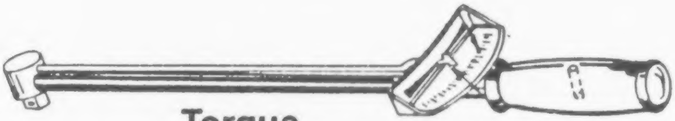
Wrenches

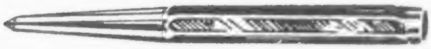

Adjustable


Hex

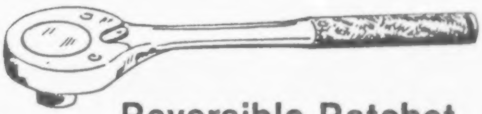

Open-End

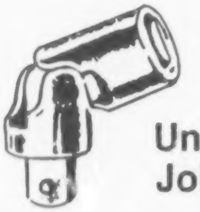

Combination


Torque

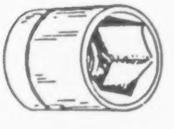

Center Punch

Cold Chisel

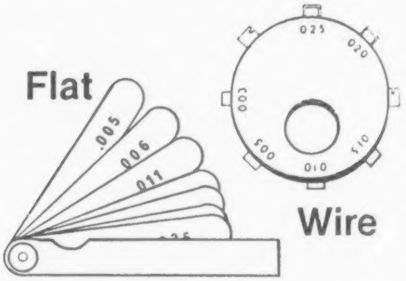

Reversible Ratchet


Universal Joint

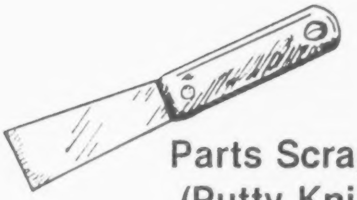
Basic Hand Tools (Continued)



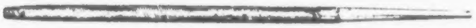
Socket


Flat
.005
.006
.011
025
020
003
005
010
015
Wire

Feeler Gauges



Parts Scraper (Putty Knife)



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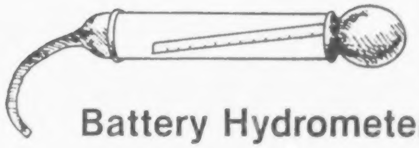
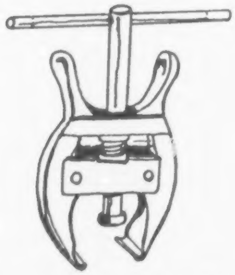
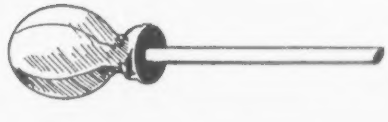


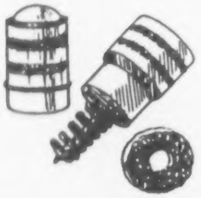
Battery Hydrometer



Battery Clamp Puller



Battery Syringe



Battery Post Cleaner

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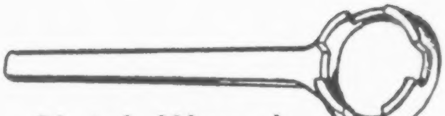
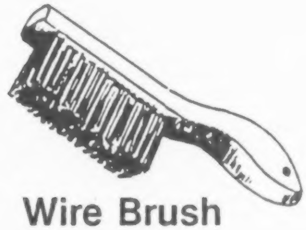
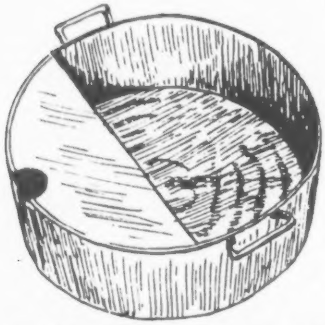
Basic Hand Tools
(Continued)



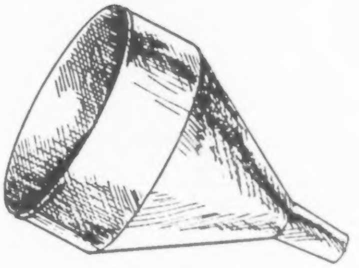
Clutch Wrench



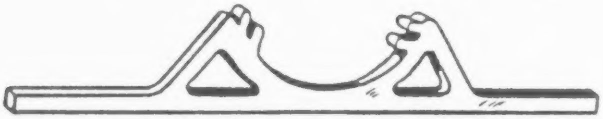
Wire Brush



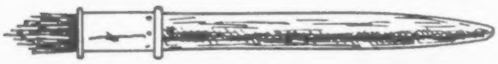
Parts Washing Container



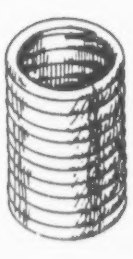
Funnel



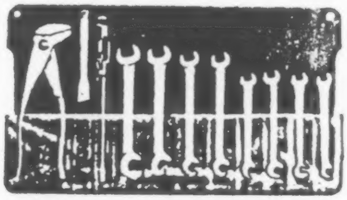
Flywheel Holder



Parts Cleaning Brush

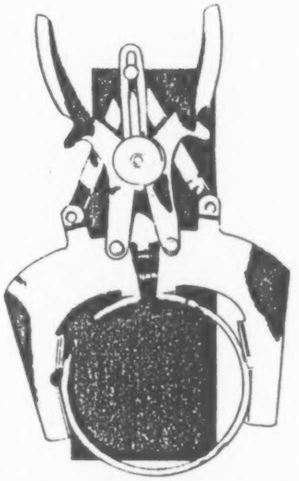


Thread Repair Insert

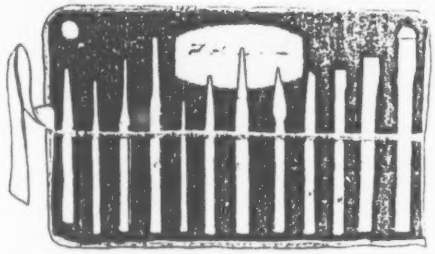


Ignition Wrench Set

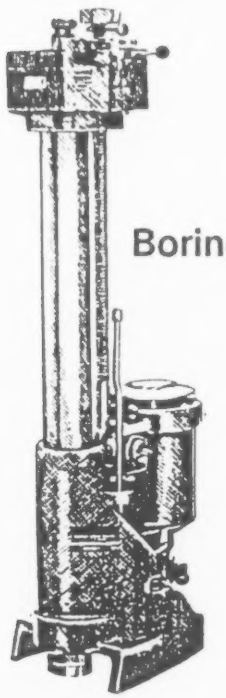
Overhaul Tools



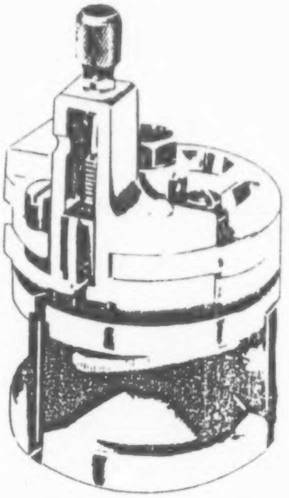
Piston Ring Expander



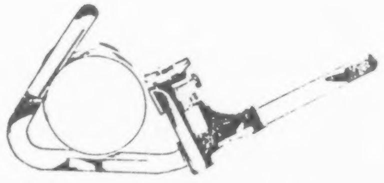
Punch and Chisel Set



Boring Bar

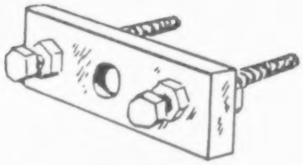


Ridge Reamer

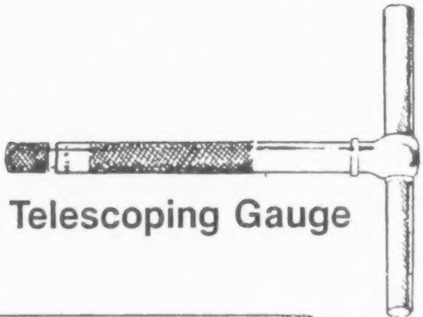


Piston Ring Groove Cleaner

Overhaul Tools (Continued)

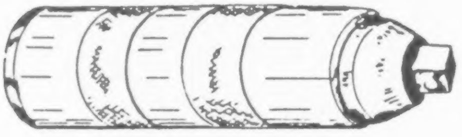


Flywheel Puller

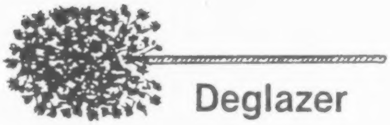


Telescoping Gauge

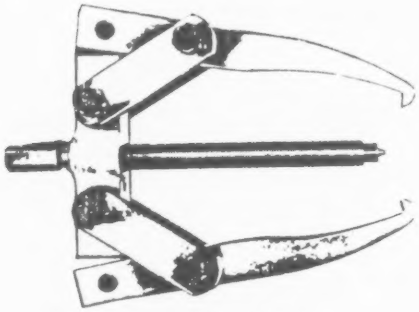
Valve Guide Reamer



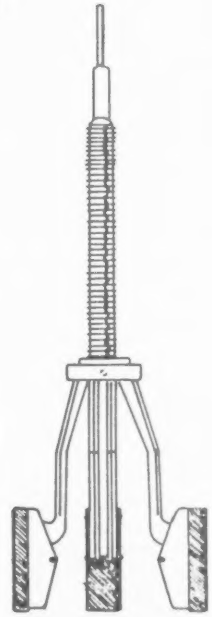
Impact Driver



Deglazer



Bearing Puller



Precision Hone

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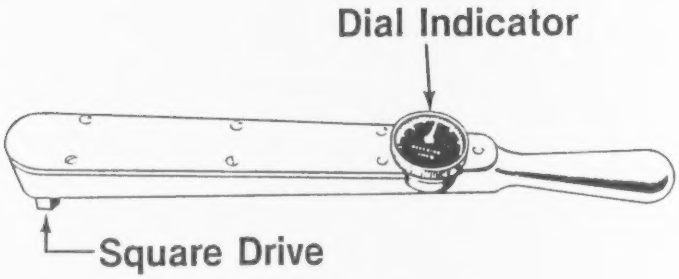
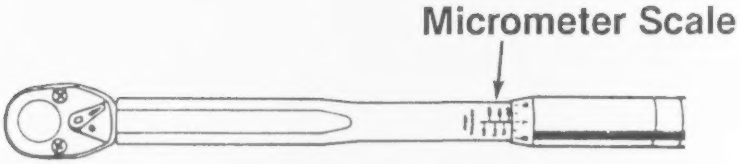
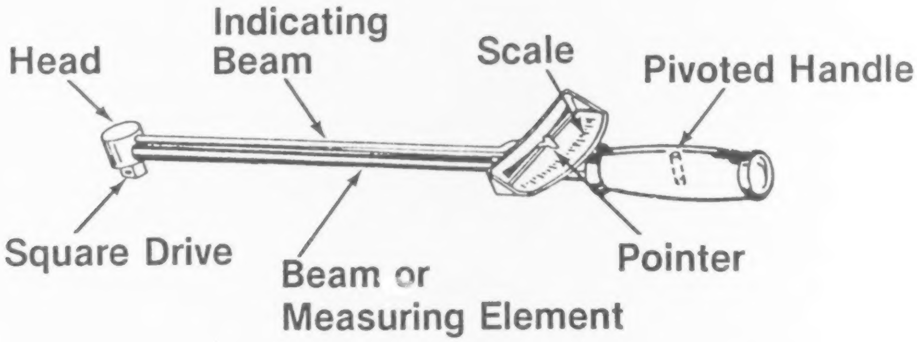
Torque Wrenches


Dial Indicator
Square Drive

Dial Indicator

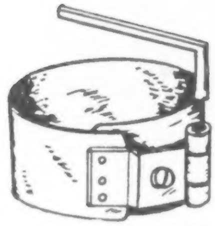

Micrometer Scale

Signaling

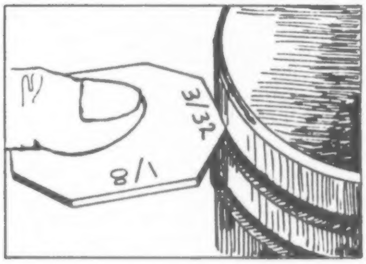

Head
Indicating Beam
Scale
Pivoted Handle
Square Drive
Beam or Measuring Element
Pointer

Direct Reading

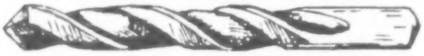
Overhaul Tools (Continued)



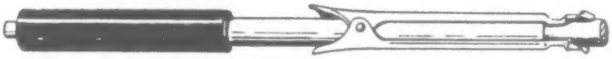
Ring Compressor



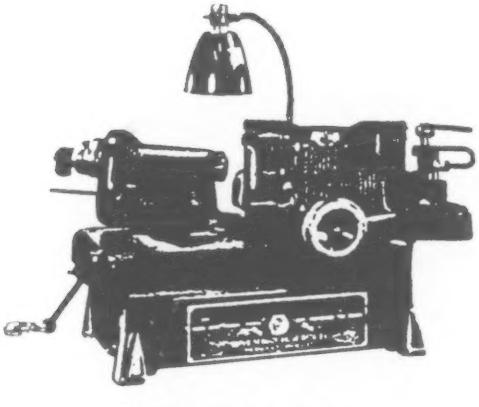
Ring Groove Gauge



Twist Drill Bit



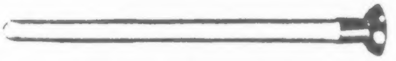
Keeper Retainer



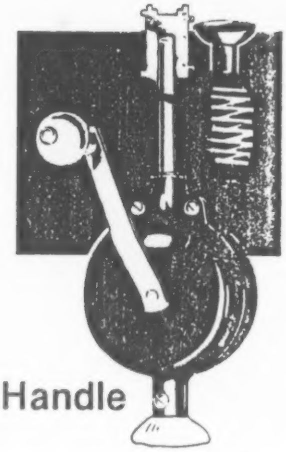
Valve Grinder

Overhaul Tools (Continued)

Valve Lapping Tool

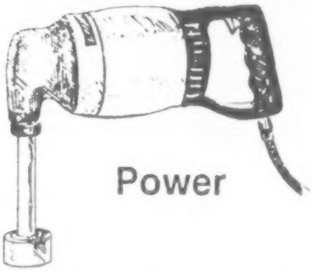


Wood Handle

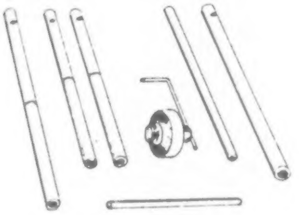


Crank Handle

Valve Seat Cutter

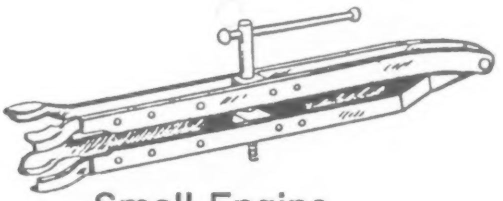


Power

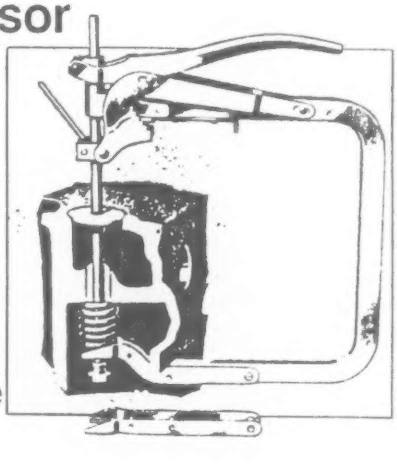


Manual

Valve Spring Compressor



Small Engine



Lever Type

APPENDIX C

GENERAL MECHANICAL REPAIR
TOOL IDENTIFICATION LIST

- Flint Striker
- Tack-Dwell Meter
- Oil Filter Wrench
- Hose clamp plier
- Open-end wrench
- Cooling system pressure tester
- Tubing cutter
- Air hammer
- Wire brush
- Jack stand
- Hydraulic floor jack
- Oxyacetylene cutting torch
- File
- Torgue wrench
- Diagonal cutting pliers
- Wheel weight tool
- Box-end wrench
- Four-way lug wrench
- Air impact wrench
- Brake adjusting tool
- Brake spring pliers
- Cylinder hone
- Portable electric drill
- C-clamp
- Outside micrometer
- Dial indicator
- Ball peen hammer
- Pin punch
- Center punch
- Needle nose pliers
- Pipe wrench
- Tie rod splitter fork
- Snap ring pliers
- Lock ring pliers
- Slide hammer puller
- Phillips screwdriver
- Nut driver
- Wire stripper/terminal pliers
- Electric soldering gun
- Battery terminal cleaner
- Socket extension
- Flat feeler gauge
- Hex key (Allen) wrench set
- Automotive timing light
- Compression tester gauge
- Flywheel holder
- Valve spring compressor
- Telescoping gauge
- Piston ring groove
- Steel tape measure
- Finishing reamer
- Combination square
- Framing square
- Power valve seat grinder
- Piston ring compressor
- Wire feeler gauge
- Spark tester (Briggs &Strattor)
- Starter clutch tool (B&S)
- Vernier caliper
- Inside micrometer
- Depth micrometer
- Die
- Tap
- Hacksaw
- Slip-joint pliers
- Standard slot screwdriver
- Offset screwdriver
- Reversible ratchet wrench
- Cold chisel
- Combination wrench
- Manual valve seat cutter
- Ridge reamer
- Valve lapping stick
- Twist drill bit
- Ignition wrench set
- Universal joint
- Standard socket
- Deep-well socket
- Flare nut wrench
- Breaker bar handle
- Speed handle
- Chipping hammer
- Manual impact driver
- Air reversible ratchet wrench
- Tubing flare tool
- Manual valve refacer
- Power valve refacer

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Officer for Civil Rights, Department of Health, Education and Welfare.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiations, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964; EXECUTIVE ORDERS 11246 AND 11375; TITLE IX, 1973 EDUCATION AMENDMENTS; REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; AND VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulations by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs or activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.